THE HIGH SPEED ELECTRONICS GROUP

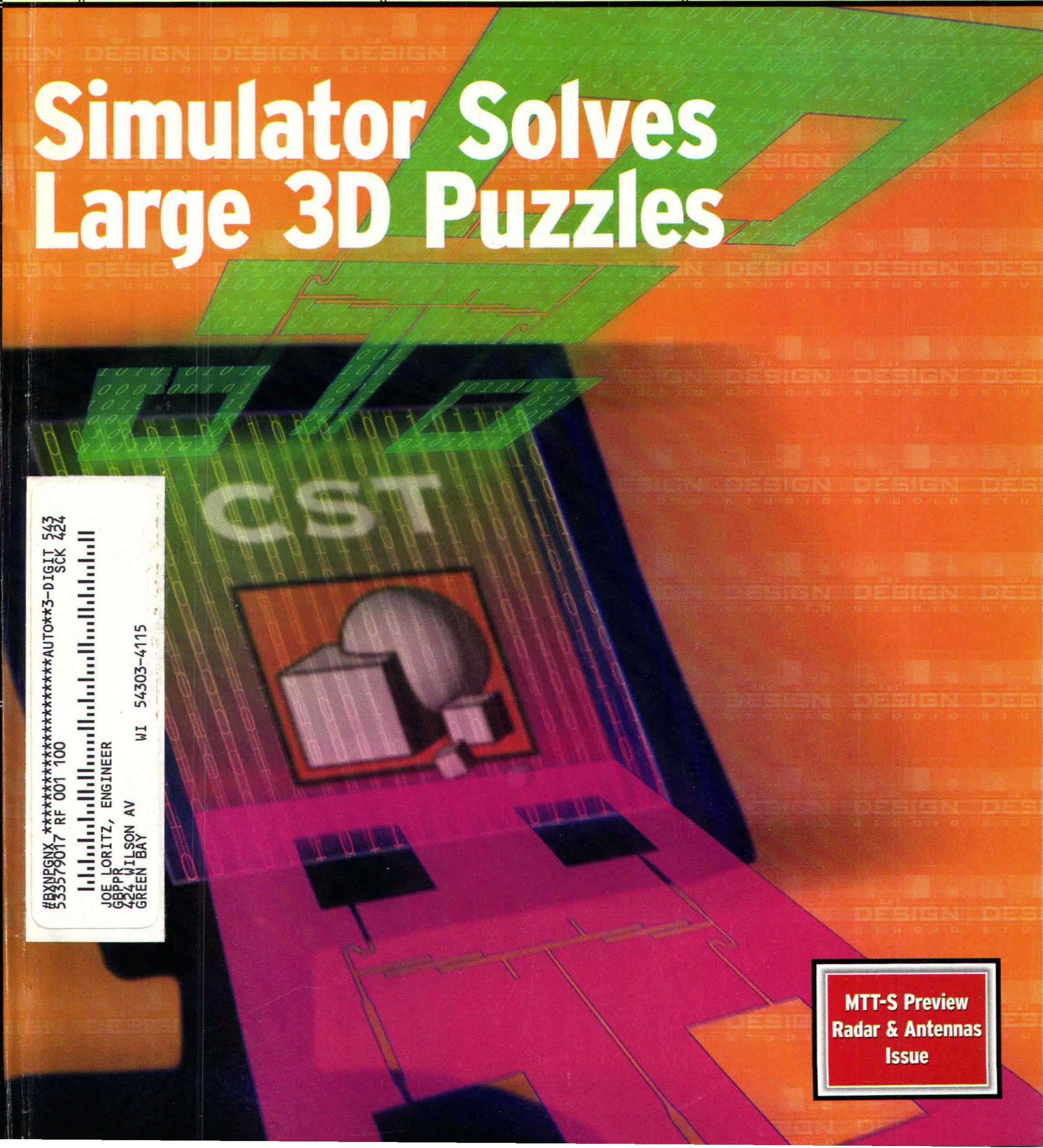
# Microwaves & RF

**News**
Technologies advance at 2002 MTT-S

**Design Feature**
EM simulator sets new speed records

**Product Technology**
Multilayer techniques shrink power dividers

# Simulator Solves Large 3D Puzzles




**MTT-S Preview
Radar & Antennas
Issue**


microwave Components
MIXERS TO 60 GHz
• Single-, double-, and triple-balanced
• Image rejection and I/Q
• Single-sideband, BPSK and QPSK modulators
• High dynamic range
• Active and passive frequency multipliers
FREQUENCY SOURCES TO 40 GHz
• Free-running VCOs/DROs
• Phase-locked cavity oscillators
• Phase-locked coaxial resonators
• Synthesizers for SATCOM
• Fast-tuning communication synthesizers
AMPLIFIERS TO 60 GHz
• Octave to ultra-broadband
• Noise figures from 0.35 dB
• Power to 10 watts
• Temperature compensated
• Cryogenic
INTEGRATED SUBASSEMBLIES TO 60 GHz
• Integrated up/downconverters
• Monopulse receiver front ends
• PIN diode switches
• Ultra-miniature switch matrices
• Missile receiver front ends
• Switched amplifier/filter assemblies
PASSIVE POWER COMPONENTS
• Power resistors and terminations
• Power dividers
• Attenuators
• Directional couplers
• 90 degree hybrids
IF AND VIDEO SIGNAL PROCESSING
• Logarithmic amplifiers
• Constant phase-limiting amplifiers
• Frequency discriminators
• AGC/VGC amplifiers
• I/Q processors
• Digital DLVAs
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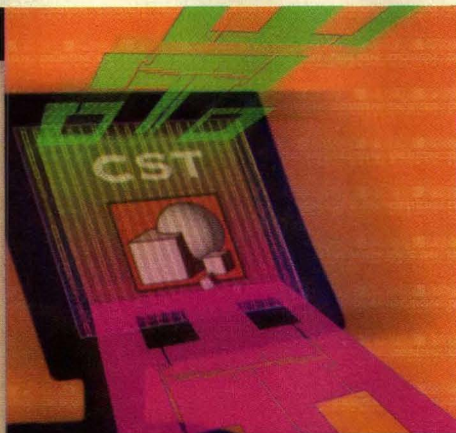


## COVER STORY



## Departments



## News



## Design



## Product Technology



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| Power Added Efficiency, % (Typ.) | 25 |
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|---|---|
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| Saturated Output Power, dBm (Typ.) | 34.0 |
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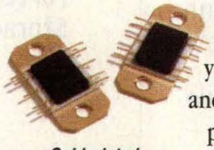

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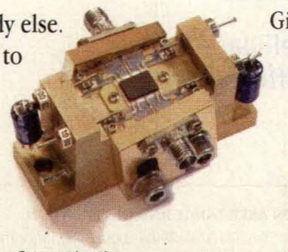

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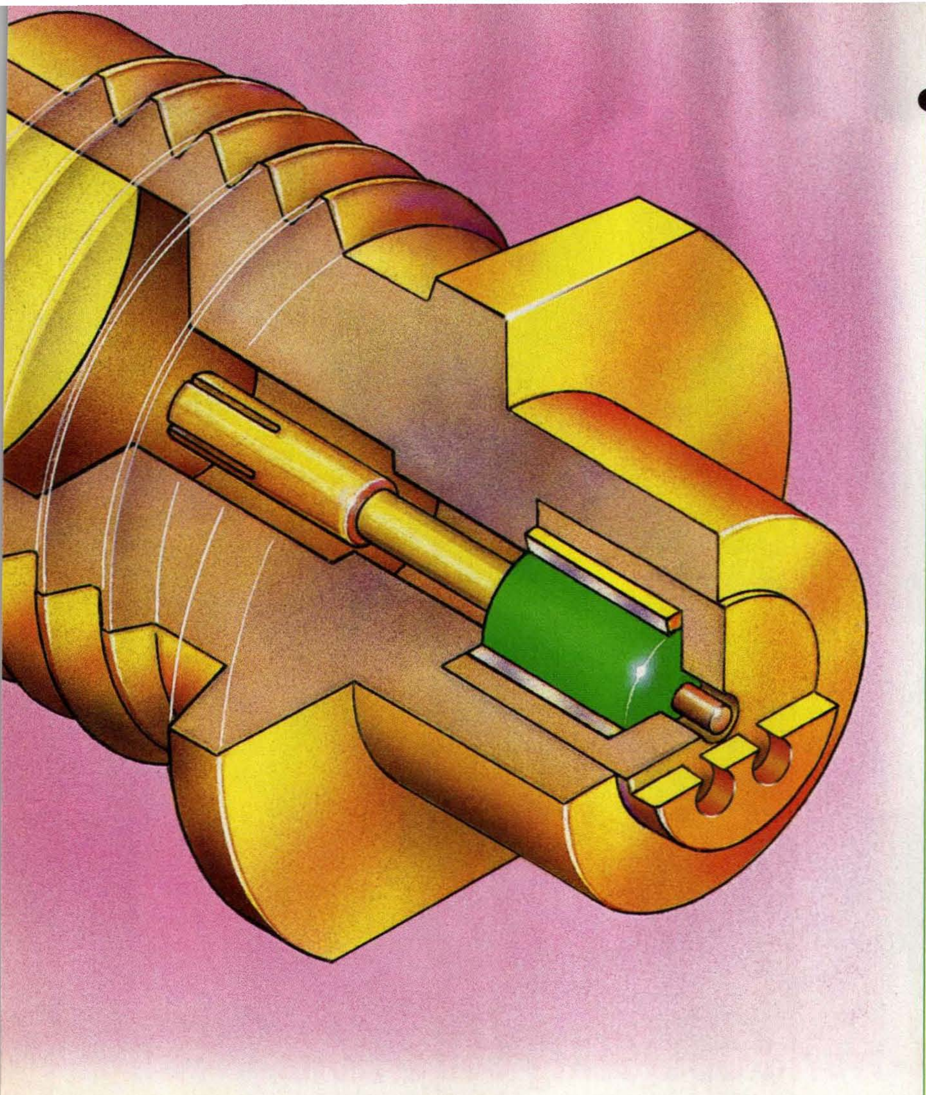

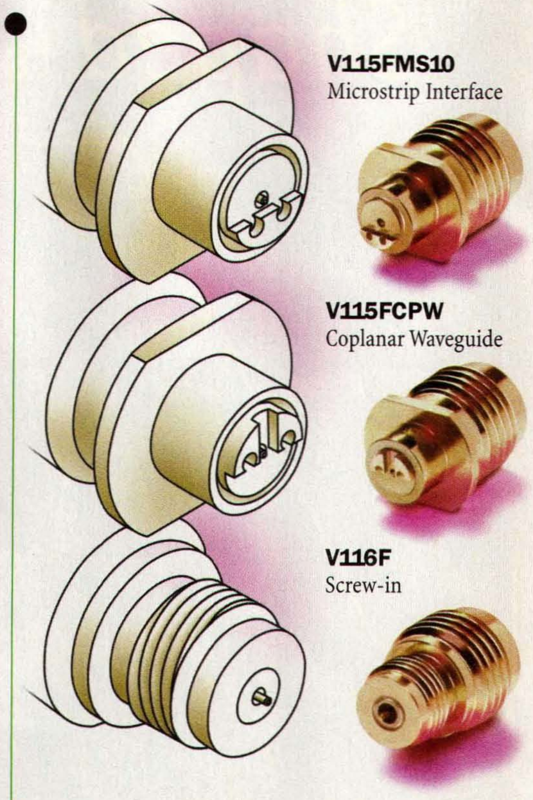


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*Patents pending

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## Windows Program

▶▶IN JANUARY 1993 you published my article on using thermistors to temperature compensate RF circuits. A Windows program has been written to run the algorithm and calculate the resistor values. The program is posted at www.Qfilter.com on the "Circuit Design" page. It is free and is easier than grinding through the equations by hand.

*Greg Adams*
IEEE

## Article Additions

▶▶I WOULD LIKE to make some additions to the February article "System Automates Accelerated Life Tests" (p. 128).

In the third paragraph, the second sentence would more accurately read "In addition, as many as 24, 48, or 96 devices can be accommodated with their AARTS DC tester" instead of reading "Up to 96 bias channels are available for power connections."

After the fourth paragraph, a paragraph could be inserted that says, "In addition to the three temperature life-test capability, the AARTS provides a semiconductor parameter analyzer, which allows the operator to perform DUT design characterization. This enables the operator to characterize the DUT more fully, using many voltage and current-stimulus options in the SPA. The analyzer drives one channel at a time, but may be multiplexed into any of the available channels."

*Barney McComas*
Marketing Communications Specialist
Maxwell Technologies, Inc.
San Diego, CA

## Anniversary Issue

▶▶I HAVE READ your August 2001 issue. The cover story on HP and the Special Section on 40 years of *Microwaves & RF* were great. The various company names brought back memories and a wonder as to what happened to some of these firms. It would be interesting to read an article (or chart) that shows where these companies (and others) are today (if they still exist).

*Tony Pizzirusso*
Senior Component Engineer
Ericsson Amplifier Technologies

## PLEASE COMMENT

*Microwaves & RF* welcomes mail from its readers. Letters should be typewritten and must include the writer's name and address. The magazine reserves the right to edit letters appearing in "Feedback." Address letters to:

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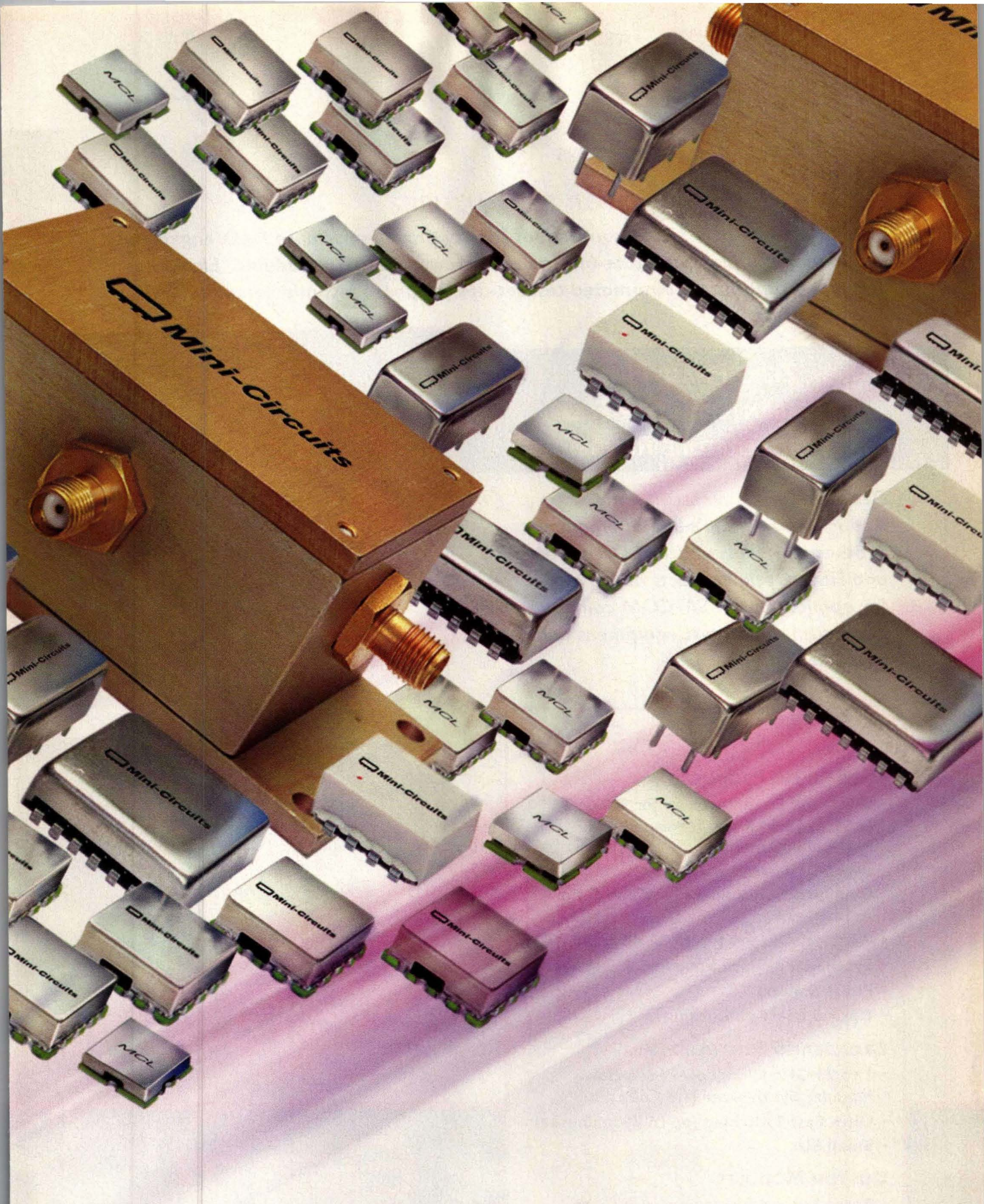
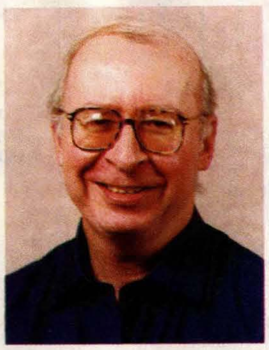

Mini-Circuits
MCL

## from the editor

# Searching For Hope At The MTT-S



Next month, thousands of high-frequency engineers will converge on the Seattle Conventional Center as part of that annual ritual known as the Microwave Theory & Techniques Symposium (MTT-S). For many, it is a chance to renew old acquaintances and make new contacts. Still, beyond the value of its technical presentations and workshops, the MTT-S serves an important function as a form of "yardstick" of the microwave industry and its relative economic health.

*The MTT-S serves an important function as a form of "yardstick" of the microwave industry and its relative economic health.*

A glance at the MTT-S technical program (see p. 33) will reveal some of the technologies making an impact, most noticeably the presence of silicon germanium (SiGe) across a wide range of technical sessions.

IBM Microelectronics deserves a great deal of credit for advancing this semiconductor technology from what was once a very low-breakdown-voltage laboratory curiosity to what is now an increasingly important semiconductor process for a growing number of application areas. In a session on cellular transceivers, for example, IBM's researchers are present with several papers that demonstrate the capabilities of SiGe bipolar complementary metal-oxide semiconductor (BiCMOS). In a session on high-speed optical integrated circuits (ICs), where indium phosphide (InP) was once dominant, SiGe was also present. Even CMOS was represented in that session as part of a presentation on 10-Gb/s (OC-192) devices.

The presence of SiGe technology could be found in a large number of presentations among the MTT-S program, including in designs for wireless data devices, receivers (Rxs), and frequency converters, 40-GHz fiber-optic devices, and even in a 36-GHz dual-modulus prescaler. The technology has even advanced to the point where several papers, including presentations from IBM and the Georgia Institute of Technology, describe the design and fabrication of SiGe heterojunction-bipolar-transistor (HBT) power amplifiers (PAs).

Yet, SiGe was not the only "emerging" technology to be found in the MTT-S program. A session on microelectromechanical systems (MEMS) features six presentations on switches, with another session detailing MEMS phase shifters and MEMS tunable capacitors. In a session on sensors, researchers from the Clemson University describe resonant-circuit sensors for remote gas sensing based on RF carbon nanotube technology.

The MTT-S will serve as a "sounding board" on which of these applications makes sense and which offer the greatest opportunities. Often, it is the exchanges of information at an event such as this that can trigger business growth.

Jack Browne

***Publisher/Editor***

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A Penton Publication

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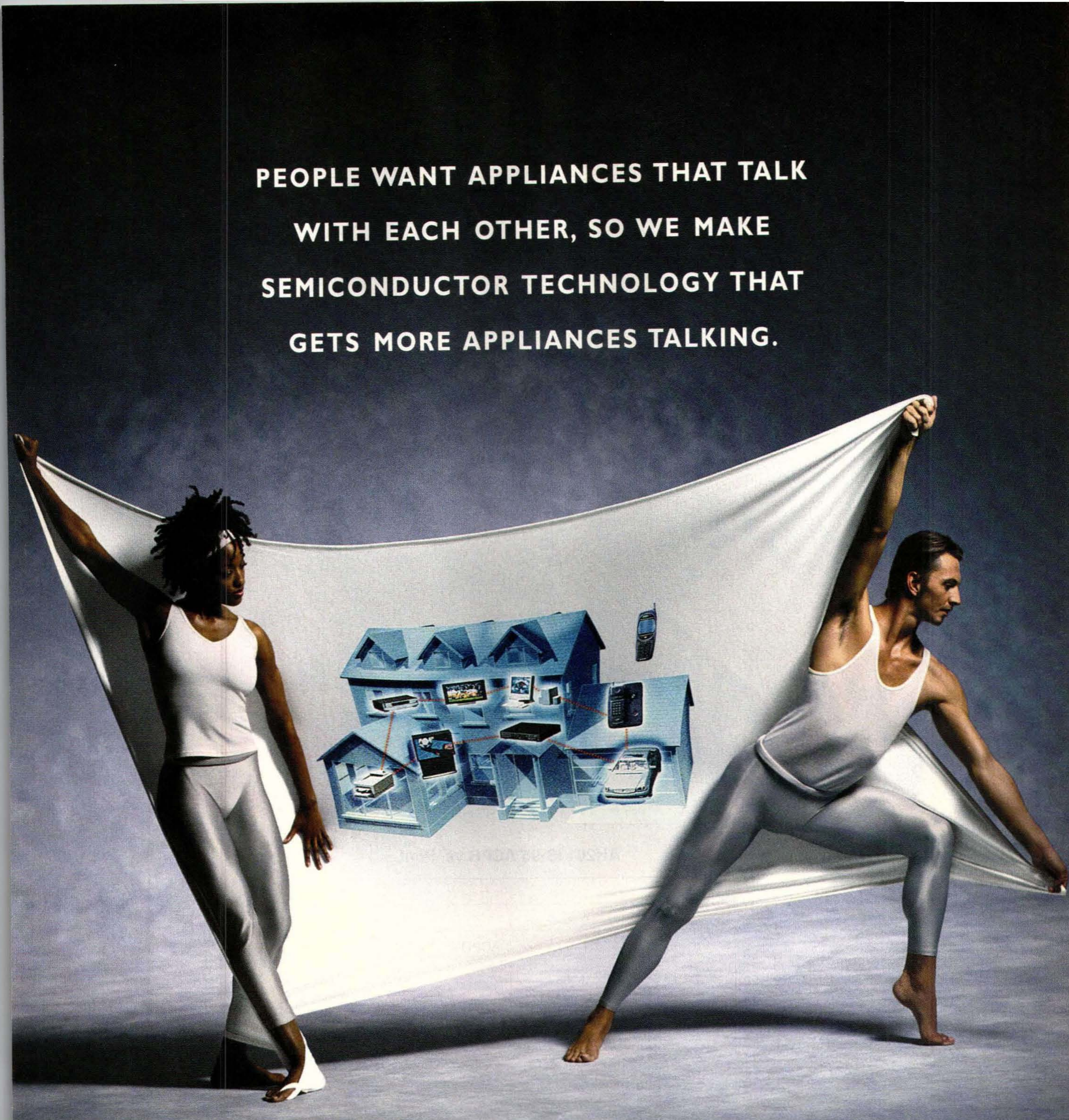

PEOPLE WANT APPLIANCES THAT TALK
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SEMICONDUCTOR TECHNOLOGY THAT
GETS MORE APPLIANCES TALKING.

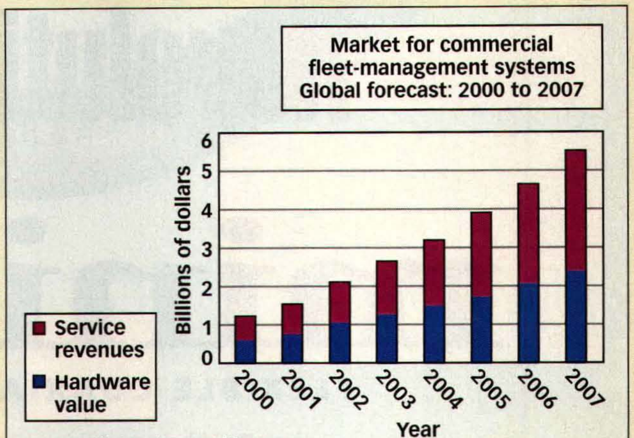
# the front end

*News items from the communications arena.*

## Commercial Telematics Market Will Thrive Over Next Few Years

*OYSTER BAY, NY*—Last year marked a considerable lull in the US commercial fleet-management-systems (FMS) industry as a result of several factors, including the economic recession, the financial difficulties in the telecom sector, and the terrorist attacks of September 11.

"Due to deteriorated market conditions, increased competition, and higher debt, many FMS vendors have been forced to restructure and focus on their core competencies," states Frank Viquez, senior analyst at Allied Business Intelligence, Inc. (ABI) and author of the report "Fleet Management Systems: A Global Analysis of Telematics Opportunities, Technologies, and Trends in Commercial Vehicle Operations." The report discusses the current status and potential for commercial telematics systems. Viquez adds that this year "will witness rising competition and market specialization, progressively more sophisticated distribution channels, and increased product differentiation in commercial vehicle telematics offerings."



Source: Allied Business Intelligence, Inc.

The commercial FMS market promises to be abundant. According to the report's findings, the global FMS market for commercial vehicles is expected to grow from under $2 billion last year to nearly $6 billion by year-end 2007 **(see figure)**. With over 200 FMS vendors in the US alone and a total addressable market of 20 million vehicles, commercial operations of interest include taxi fleets, leased fleets, heavy trucks and equipment, transit fleets, and emergency vehicles.

## Start-Up Firm Offers Complete Optoelectronic Front-End ICs

*SUNNYVALE, CA*—Focused on designing, manufacturing, and selling optoelectronic integrated circuits (OEICs) for next-generation, high-speed optical communications systems, OEpic, Inc. (pronounced 'epic') introduced its first products at the recent OFC Conference in Anaheim, CA.

Formed in July 2000, OEpic has developed OEIC design and indium-phosphide (InP) device technologies in its own manufacturing facility, permitting the integration of optical and electronic devices for speeds up to 40 Gb/s.

The company was formed by an experienced team with extensive backgrounds in optoelectronic and microwave technologies, and has received more than $30 million from several venture capitalists and corporations.

According to Dr. Yi-Ching Pao, co-founder, board member, president, and CEO, "We've assembled a world-class team of talents, and secured the backing of some of the most experienced investors, to be the vendor of choice for front-end solutions in next-generation optical-communications systems. What we call 'OEpic Up Front.' We're generating revenue within 18 months of our founding, and we have contracts with strategic partners. The need for more information, more quickly, will never go away and we intend to be a key player in the next wave of growth."

In addition to offering complete chip-set solutions ranging from 10 to 40 Gb/s, OEpic also supports specific customer applications where custom designs permit more effective solutions for specific markets.

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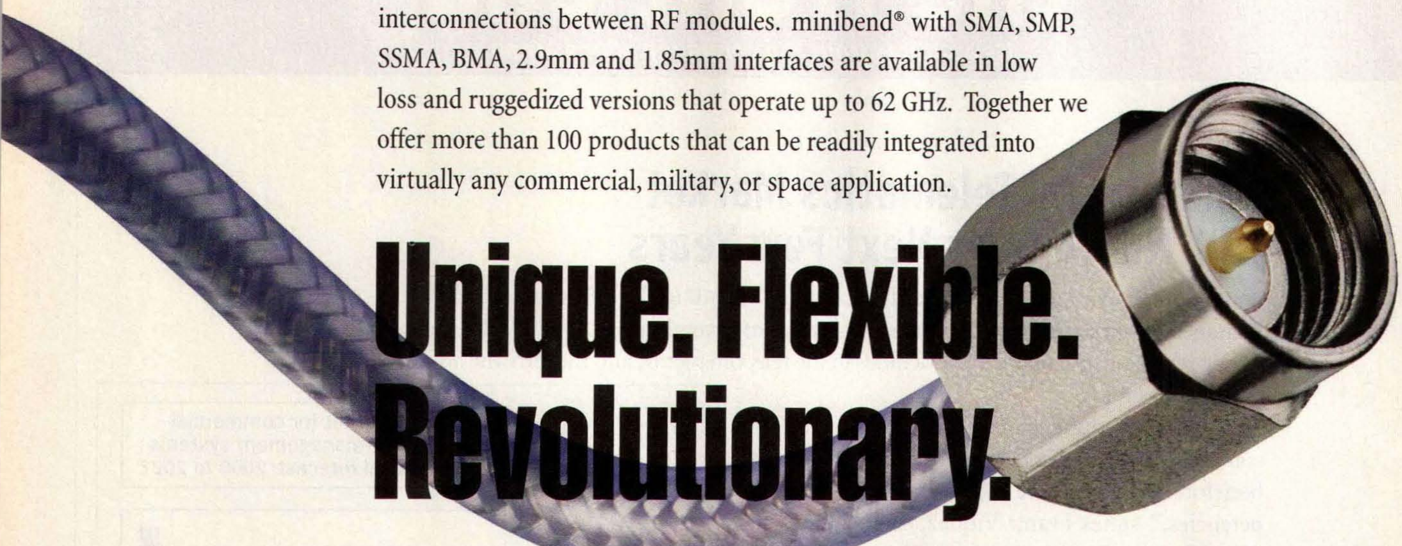

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## UK Broadband Fees Are Drastically Slashed

*LONDON, ENGLAND*—In an effort to increase demand for broadband Internet access among UK consumers, British Telecommunications plc (BT) has implemented dramatic price cuts. Great Britain has one of the lowest broadband penetration rates in the industrialized world. (See "Broadband Penetration Is Low In The United Kingdom," March 2002, p. 24.)

Ben Verwaayen, BT's chief executive, says, "Broadband is the future for Britain and we're putting it at the heart of BT's plans for growth in the UK mass market. This will drive the whole market forward by making broadband affordable, attractive, and accessible."

"Broadband is the future for Britain."

Verwaayen revealed BT's plans to target one million asymmetric-digital-subscriber-line (ADSL) broadband connections over BT's network by summer 2003. The steps that will be taken include:

1. Cutting wholesale line rental for consumer connections from 25 to 14.75 UK pounds (approximately \$35.59 to \$21.00) a month as of April 1st.
2. Improving the experience of BT's Wholesale customers and end-users through better network performance and service quality.
3. Boosting marketing, including joint projects between BT Wholesale and more than 40 service providers, to champion the benefits of broadband.
4. Encouraging all service providers, including BTopenworld, to use the wholesale saving to set new prices for consumers and businesses and to mount their own campaigns to promote broadband.
5. Searching actively for partnerships to extend broadband to less commercially viable areas.

Verwaayen says, "This is a stretching program, but achievable. Through substatial reductions in the cost of providing service we can set prices that will stimulate the market strongly, and make money on it. This is a sustainable business model.

"We are committed to making broadband widely available. We are driving for growth across the entire market. To be sure of meeting these targets we need the support of the entire broadband community, including partially content creators and providers."

Paul Reynolds, CEO of BT Wholesale, comments, "We have now achieved the price that service providers told us they needed to get end-user prices below 30 pounds (approximately \$42.71). We have made sustained improvements in network service levels in recent months and are taking action on automation to help service providers to improve the customer experience even further.

"We expect these new low prices to drive up demand for broadband. Now the momentum for broadband take-up should build. [This] announcement is a first step, but a significant one."

## Patent-Infringement Case Is Decided

*SAN DIEGO, CA*—Qualcomm, Inc. announced that it has won summary judgement in its patent-infringement litigation with GTE Wireless, Inc. In an order dated February 14, 2002, Judge Rudi M. Brewster of the US District Court for the Southern District Court of California granted Qualcomm's motion for a judgement that Qualcomm's products do not infringe any of the claims at issue of US Patent No. 4,916,728. The Court ruled that Qualcomm's products do not infringe the patent as a matter of law. GTE asserted that the '728 patent covers the way in which cellular telephones determine which cellular system to use for a particular call when multiple systems are detectable by the phone. The Court held that the way in which the Qualcomm products perform this function was substantially different from the way it was claimed in the patent as a matter of law. The Court simultaneously denied GTE's motion for summary judgment of infringement.

"Qualcomm is gratified that its strongly held position has been vindicated," says Lou Lupin, general counsel and senior vice president of Qualcomm. "Because proprietary technology is the lifeblood of our company, we have a profound respect for intellectual-property rights. That respect compels us not only to honor meritorious claims but to vigorously contest meritless claims."

GTE originally filed this case in Virginia in June 1999 but Qualcomm's motion to transfer the case to the federal court in San Diego was granted in September 1999. The Court's grant of summary judgment in Qualcomm's favor comes one week after oral arguments on the parties' motions.

On another patent matter, Qualcomm also had patents for its code-division-multiple-access (CDMA) systems held up by patent offices in Europe, Korea, and Japan.

## Agreement Is Reached For Development Of PIN Receivers

*SAN JOSE, CA*—Fujitsu Quantam Devices Ltd., Fujitsu Compound Semiconductor, Inc., and JDS Uniphase Corp. have announced a multi-source agreement (MSA) for the development of compact 40-Gb/s PIN receivers (Rxs) with differential coplanar outputs for 40-Gb/s fiber-optic system applications.

This compact, differential coplanar MSA Rx design reduces the space required on 40-Gb/s circuit packs, cancels common-mode noise at the clock-and-data-recovery (CDR) circuit, and doubles the output-voltage swing compared to single-ended designs. These MSA Rxs are compatible with advanced decision thresholding techniques using differential monitor outputs, and threshold-control inputs.

"Proprietary technology is the lifeblood of our company."

The MSA specifies the maximum Rx package outline, pin function definitions, and pin locations for single-mode fiber pigtailed, 40-Gb/s PIN Rx modules. The flange-mount package is approximately 24 × 38 × 7.4 mm in size. Sample products are expected to be available next month.

## Kudos

*HOUSTON, TX*—Mimix Broadband, Inc., a developer of gallium-arsenide (GaAs) monolithic microwave integrated circuits (MMICs), announced that the company's Australia Design Center subsidiary has been registered to ISO 9001, the internationally recognized quality-management system standard administered by the International Organization for Standardization. Det Norske Veritas Certification, Inc. (DNV) awarded Mimix's Australia Design Center with its certification to ISO 9001, which consists of stringent specifications that outline practices to ensure design control, maintenance of product and service quality, and continuous quality improvement.

*PRESTEIGNE, UNITED KINGDOM*—Labtech, part of the Intelek Group and UK-based manufacturer of microwave printed-circuit boards (PCBs), has announced its receipt of Underwriters Laboratory (UL) approval for softboard circuits manufactured using specialist microwave substrates RF35 and RF35P from Taconic.

*VISTA, CA*—Palomar Technologies' chairman Gary Gist and president Kevin Conlon were named as two of *Fortune* magazine's "Heroes of U.S. Manufacturing," an annual special section honoring companies that have achieved innovation in US manufacturing technology. The section was published in *Fortune's* Industrial Management & Technology edition on March 18, 2002.

*LANHAM, MD*—Vocus, Inc., a provider of Web-based public-relations-automation (PRA) software, was selected from more than 150 nominees to receive Honorable Mention for the "innovation of the Year" award sponsored by *PR Week*. The 2002 PR Week Awards showcase the best in public relations and recognize outstanding achievement in 30 categories. Winners were announced on February 21st during a ceremony at the Tavern on the Green restaurant in New York's Central Park. Vocus was the only software company to be nominated for the award.

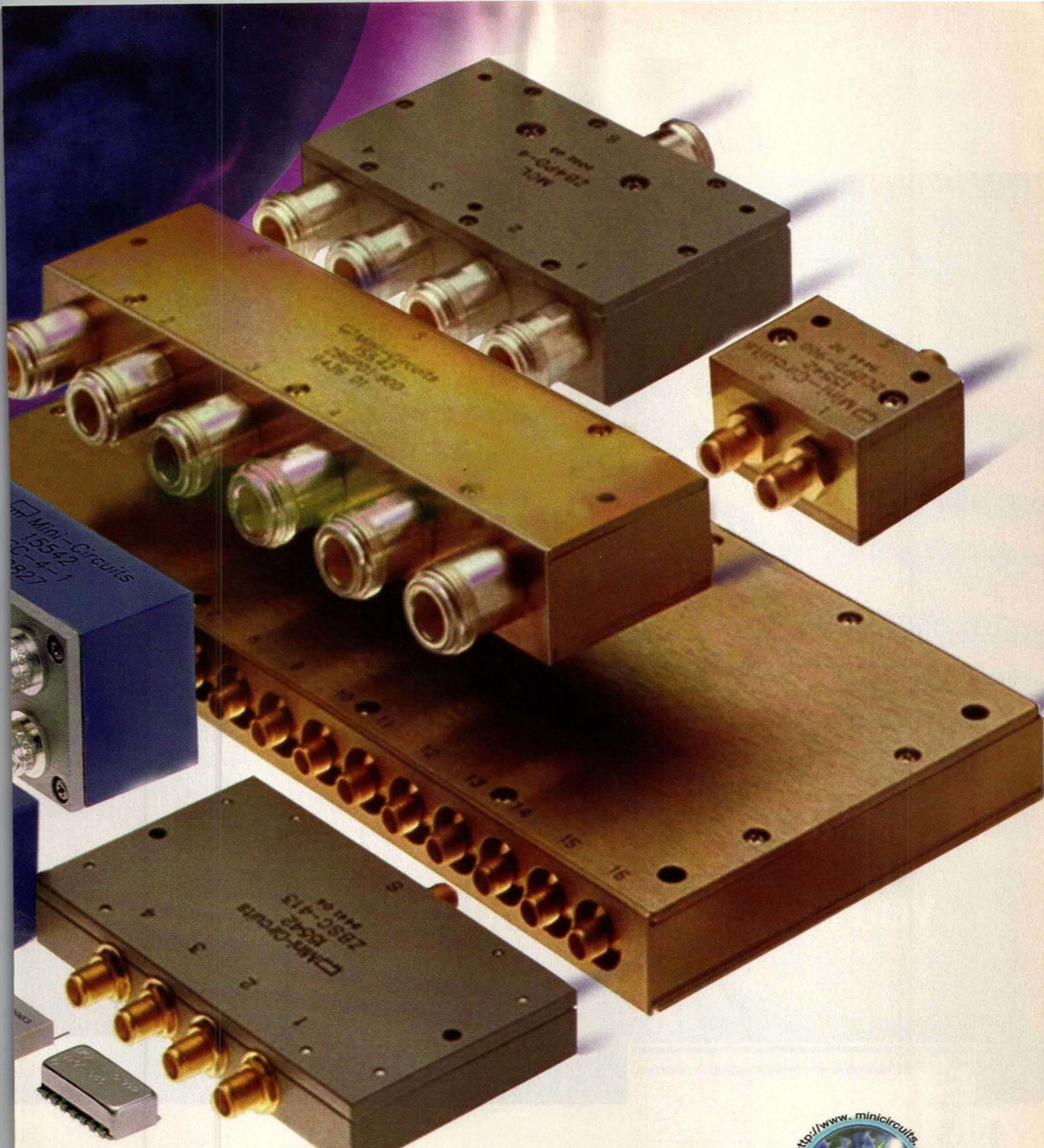
*PITTSBURGH, PA*—The editors of *Automotive Engineering International* (AEI) presented Ansoft Corp. with an AEI Tech 2002 Award at the Society of Automotive Engineers (SAE) World Congress, which was held in Detroit, MI on March 4-8.

AEI editors, who give the award annually to companies that feature top new products and technologies at the show, awarded Ansoft for its release of SIMPLORER®, a multidomain simulation package for the design of electrical and electromechanical systems in automotive power electronics and industrial automation.

*PLUMSTEADVILLE, PA*—The Compressed Gas Association (CGA) recently honored Scott Specialty Gases at its Annual Meeting in Tampa, FL by naming Scott as recipient of the Leonard Parker Pool Safety Award for 2001. This is the third time that Scott has been recognized by the CGA. Scott also received the safety award in 1989 and 1998.

The Leonard Parker Pool Safety Award was initiated in 1978 to honor participating CGA members who have shown the greatest improvement in safety performance. Each year, an Association member company from each of three levels of employee exposure hours is honored for having the highest percentage of improvement involving annual occupational injury and illness. Scott was honored for having the greatest improvement in safety among companies having between 400,000 and 1.5 million employee exposure hours.

*BOSTON, MA*—The U.S. Small Business Administration (SBA) has named Ronald S. Contrado, president and CEO of Homisco, Inc., the Massachusetts 2002 Small Business Exporter of the Year. MRF



NEWS

# Seattle Is Home To 50th MTT-S Show

## Since 1952, the microwave industry has convened annually at the MTT-S Show where technical sessions have been given and key products have been shown.

**This year, the Microwave Theory & Techniques Symposium (MTT-S) will be celebrating its 50th Anniversary in the Pacific Northwest. Held from June 2-7, 2002 in Seattle, WA, the MTT-S will deliver a large variety of technical sessions (see table) as many of the industry's exhibitors will be showcasing their latest and hottest new products to the engineering community and to other industry professionals.**

**JACK BROWNE**
Publisher/Editor

**PETER STAVENICK**
Managing Editor

**MITCHELL GANG**
Copy Editor

The conference opens with workshops on June 2, and continues on June 3 with the 2002 RFIC Symposium's technical sessions. The RFIC Symposium begins session MO2A on Cellular Transceivers, chaired by S. Lloyd and Co-Chair J.P. Mondal. Additional RFIC Symposium sessions include session MO2B on "Efficiency Enhancement Techniques for Handset Applications," session MO2C on "Integrated VCO," session MO2D on "Optical System ICs," session MO3A on "Wireless Data System ICs,"session MO3B on LNAs, Mixers, and Switches," session MO3C on "High Frequency Receiver and Converter Technology," session MO3D on "PLL and Frequency Synthesizer," and session MO4D on "Cellular Systems and Chip Sets."

Tuesday, June 4, formally begins the MTT-S technical sessions with a special session chaired by R. Weigel and co-chaired by C.C.W. Ruppel, "Special Session on Radio-Frequency Integrated Circuits for 3G." Additional sessions that day include session TU2B on "MMIC Technology," session TU2C on "Phased Arrays and Beam Steering Techniques," session TU2D on "Integrated Circuits for 40-Gb/s Fiber Systems," session TU2F on "Nonlinear CAD Techniques for Circuits and Systems,"session TU3B on "SiGe RFIC Process Technologies," session TU3D on "RF MEMS Switch Design and Modeling," session TU3E on "Frequency-Conversion Circuits," session TU4A on "Active Device Modeling and Characterization," session TU4B on "RF IC Power-Amplifier Technologies," session TU4D on "Application

**RFIC And IMS Technical Sessions**

| SESSION DAYS AND TIMES | 8:00 TO 9:40 AM | 10:10 TO 11:50 AM | 1:20 TO 3:00 PM | 3:30 TO 5:10 PM |
|---|---|---|---|---|
| Monday | | MO2 | MO3 | MO4 |
| Tuesday | | TU2 | TU3 | TU4 |
| Wednesday | WE1 | WE2 | WE3 | WE4 |
| Thursday | TH1 | TH2 | TH3 | TH4 |

of RF MEMS," and session TU4E on "Frequency and Phase Control Circuits."

## Wednesday's Sessions

Wednesday, June 5th, is the second day of the MTT-S papers and the last day of RFIC Symposium. MTT-S sessions include the humorously titled "High-Power Amplifiers WATTS UP?" (session WE1A), session WE1B on "Microwave and Millimeter-Wave Sensor Applications," session WE1C on "Transmission Line Structures," session WE1C on "Advances in Microwave Oscillators," session WE1E on "Linear Modeling," session WE1F on "Advances in Time-Domain Techniques for EM Field Modeling," session WE2A on "Distortion Correction Techniques for High-Power Amplifiers," session WE2B on "Evolving Communications and Radar Systems," session WE2C on "Transitions, Polarizers, and Coupling Characteristics in LTCC," session WE2D on "Microwave and mm-wave Signal Generation," session WE2E on "Nonlinear Device Modeling," and session WE2F on "Applications of the Finite-Difference Time-Domain Method."

"Applications of the Finite-Difference Time-Domain Method" is the focus of session WE2F with Chair E.M. Tentzeris and Co-Chair Luca Roselli. N. Bushyager *et al.*, of the Georgia Institute of Technology, discusses "Modeling and Optimization of RF-MEMs Reconfigurable Tuners With Computationally Efficient Time-Domain Techniques."

"Power-Amplifier Technologies for Broadband, High-Efficiency Applications" is chaired by A. Platzker and co-chaired by P. Asbeck. Cynthia Hang *et al.*, of the University of California at Los Angeles, will focus on "A New Amplifier Power-Combining Scheme with Optimum Efficiency Under Variable Outputs."

Chair S.D. Pritchett and Co-Chair S.L. March will moderate session WE3B "Direct-Conversion Techniques for Wireless Systems." J.C. Schiel *et al.*, of the Ecole Polytechnique de Montreal will discuss the paper "Six-Port Direct-Digital-Receiver And Standard-Direct-Receiver Results for QPSK Modulation at High Speeds."

Session WE3C is "New Leakage Effects on Printed-Circuit Transmission Lines." Chaired by J. Zehentner and co-chaired by H. Shigesawa, the session features a paper given by M. Tsuji *et al.*, of Doshisha University titled "Significant Contribution of Non-physical Leaky Mode to the Fields Excited by a Practical Source in Printed-Circuit Transmission Lines."

"Efficient Modeling Techniques for Circuit Simulation" is the focus of session WE3D, which is chaired by A.K. Sharma and co-chaired by R. Goyal. Fea-

turing a paper given by S. Ramberger *et al.*, of the Fraunhofer Institute for Applied Solid-State Physics in Germany, the title is "A Symmetry Device to Speed Up Circuit Simulation and Stability Tests." Houfei Chen *et al.*, of the University of Washington, Seattle, will talk about the paper "Coupling of Large Number of Vias in Electronic Packaging Structures and Differential Signaling."

"RF Power Amplifiers for Wireless Applications" is the subject of session WE4A. Chaired by C.E. Weitzel and co-chaired by A. Pham, Motorola's E. Lan *et al.* will give a paper on "InGaP PHEMTs for 3.5-GHz WCDMA Applications."

O. Boric-Lubecke *et al.*, of Bell Labs, Lucent, will talk about the paper "DCS-1800 Base-Station Receiver Integrated In 0.25-μm CMOS" during session WE4B. Titled "New Technologies for Communications Systems," the session is chaired by J. Sitch and co-chaired by J.B. Horton.

Chair A. Omar and Co-Chair D.R. Jackson will lead the WE4C session on "New Periodic Structures and Effects." N. Shino *et al.*, of the University of Colorado, will present "Radiation from Ground-Plane Photonic Bandgap Microstrip Waveguides" during the session.

The WE4D session on "CAD Techniques Using Computational Intelligence" is chaired by K.C. Gupta and co-chaired by Q.J. Zhang. University of Waterloo's V. Miraftab *et al.*, will talk about the paper "Computer-Aided Tuning of Microwave Filters Using Fuzzy Logic."

S. El-Ghazaly and W. Gwarek will be the chair and co-chair, respectively, of session WE4E "Applications of Time-Domain Methods." No-Weon Kang *et al.*, of Seoul National University, will discuss "A New 2D Image Reconstruction Algorithm Based on Fdtd and Design Sensitivity Analysis."

The last session day is Thursday, June 6. Session TH1A will discuss "Flip-Chip Techniques and Novel Application of Organic Materials in Packaging." R. Ramachandran *et al.*, of Clemson Uni-

versity, will talk about "Development of an Organic Wafer-Level Packaging Platform for Highly Integrated RF Transceivers." W. Heinrich is the chair and Drayton will be co-chair of this session.

Session TH1B is about "Low-Noise Devices and Applications." Sungmin Ock *et al.*, of Future Communications IC will cover "A Modified Cascode-Type Low-Noise Amplifier Using Dual Common-Source Transistors." The chair will be M.S. Gupta with T.C. Cisco as co-chair.



"Synthesis and Multimode Techniques" is the subject of session TH1C. Chaired by W.C. Tang, L. Accatino *et al.*, of Telecom Italia Lab (Torino), will discuss "Dual-Mode Filters with Grooved Dielectric Resonators for Cellular-Radio Base Stations."

"Special Session on High-Speed/Non-contacting Electrical Probing" will be the TH1E session topic as invited paper author Wolfgang Mertin will discuss "Contactless Probing of High-Frequency Electrical Signals with Scanning Probe Microscopy." The session is chaired by Dylan Williams and co-chaired by Paul Hale.

Dev Palmer and Amir Mortazawi will be the chair and co-chair, respectively, of session TH1F's "Spatial Power Combining and Quasi-Optical Techniques." B.H. Strassner *et al.*, of Texas A&M University, will talk about "A Circularly Polarized Rectifying Antenna Array for Wireless Microwave Power Transmission with Over 78-Percent Efficiency."

Chair P.H. Siegel and co-chair M. Afsar will run session TH2B. Titled "Special Session on THz Technology and Applications," M.J. Coulombe *et al.*, of the University of Massachusetts (Lowell), will discuss the invited paper "Submillimeter-Wave Polarimetric Compact Ranges for Scale-Model Radar Measurements."

Session TH2C, deals with "Novel Filter Structures." "A Ku-Band Low-Loss Stripline Lowpass Filter for LTCC Modules with Low-Impedance Lines To Obtain Plural Transmission Zeros" will be covered by T. Ohwada *et al.*, of Mitsubishi Electric Corp. The chair will be S. Kanamaluru and the co-chair will be A.E. Atia.

R. Henderson and R.D. Pollard will be the chair and co-chair of "Microwave Measurements 1," session TH2E. Z. Ma *et al.*, of Saitama University will discuss "Error Analysis of the Unloaded Q-Factors of a Transmission-Type Resonator Measured by the Insertion-Loss Method and the Return-Loss Method."

"Microwave Photonics" is the TH2F session as Chair Dieter Jaeger and Co-Chair Charles Cox moderate a paper

# Eyeing The Potential Of Emerging Technologies

**JACK BROWNE**
Publisher/Editor

Advances in RF/microwave technologies come steadily with time as the result of small "breakthroughs" in physics and other areas. During the 1980s, for example, research on high-electron-mobility-transistor (HEMT) structures led to practical devices that are now the basis for many low-noise RF and high-speed optical semiconductors. Numerous "laboratory" technologies are beginning to now emerge in practical forms and should have significant impact on RF and microwave design for years to come.

In the 1980s, much of the high-frequency semiconductor debate centered on whether gallium-arsenide (GaAs) would ever replace silicon (Si). As the performance of GaAs metal-semiconductor-field-effect-transistor (MESFET) structures improved, low-noise and power GaAs field-effect-transistor (FET) devices became commonly used in high-frequency satellite and terrestrial receivers (Rxs) and transmitters (Txs). But as the HEMT structure became more widespread, GaAs HEMT devices gradually displaced FETs for high-frequency applications that required good low-noise performance.

Today, at frequencies below 3 GHz (where the majority of wireless applications can be found), Si germanium (SiGe) has emerged as a strong candidate for low-noise and medium-power applications. For example, SiGe Semiconductor (Ottawa, Ontario, Canada) has shipped more than 2 million SiGe devices during 2001, and recently added SiGe bipolar-complementary-metal-oxide-semiconductor (BiCMOS) power amplifiers (PAs) to their product lineup. SiGe Semiconductor is also working with Cypress Semiconductor (San Jose, CA) on clock drivers and other communications devices designed to incorporate SiGe in BiCMOS.

SiGe is also finding use in "commodity" type electronic applications. In low-cost television tuners, for example, SiGe tuner integrated circuits (ICs) are now replacing a market long held by GaAs, as companies such as Zarlink Semiconductor and Microtune (Plano, TX) supply SiGe RF tuners for cable modems and digital set-top boxes. IBM (Lowell, MA), the pioneer of SiGe semiconductors, has recently pushed the cutoff frequency of their transistors to 210 GHz, using a SiGe process with copper (Cu) interconnects. The company earlier this year announced PA devices capable of breakdown voltages beyond +7 VDC for wireless/cellular applications. The number of firms with SiGe process capability has grown steadily, and now includes Agere Systems, Conexant, IBM, Infineon, Intersil,

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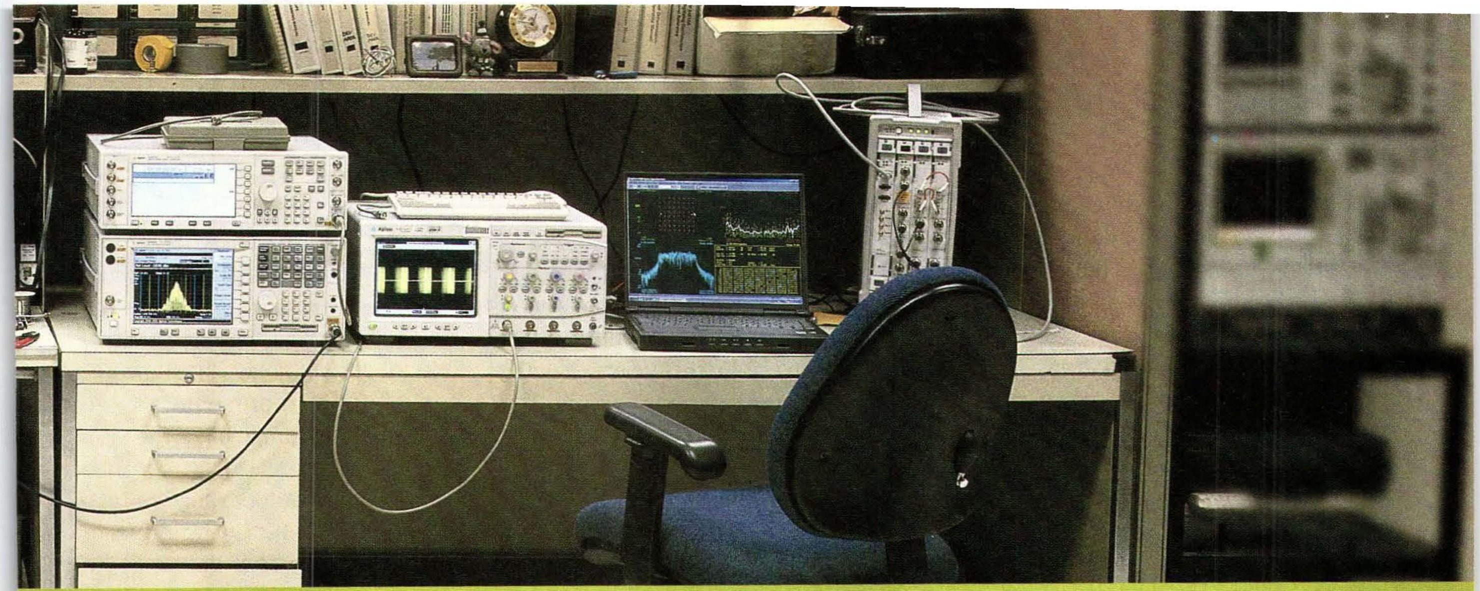
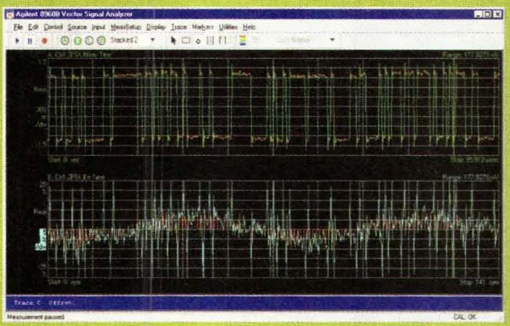


To achieve *Bluetooth* qualification, your product must pass all 16 sections of the RF test specification. From what we've seen, test results are as unique as every design and no single test yields consistent failures. However, most receivers exceed the sensitivity specification so the nine transmitter tests tend to be the biggest concern.

Problems are often specific to the type of transmitter. In FM-based designs, frequency drift is a common issue. Digital noise on the power supply can affect modulators and VCOs, producing ripple in a frequency drift measurement. For IQ-based modulators, the culprit is often modulation quality. They're not called out in the test specification, but measurements such as FSK error, magnitude error and the eye diagram help identify modulation quality problems.



*The FSK error display can highlight the effects of unwanted frequency modulation, which may indicate the presence of spurious signals in the modulator.*

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given by L.A. Johansson *et al.*, of the University College, London. The paper is titled "Optical Delivery of Modulated Millimeter-Wave Signals Using Free-Running Laser Heterodyne with Frequency-Drift Cancellation."

"Advanced V-Band Transceiver Technology" (session TH3A) is moderated by Chair E.C. Niehenke and Co-Chair P. Saunier. A. Yamada *et al.*, of Sharp Corp., will present the paper "A Compact 60-GHz Subharmonically Pumped Mixer MMIC Integrated with an Image-Rejection Filter."



## Eyeing The Potential (cont'd)

*continued from page 40*

Maxim, Motorola, Philips, STMicroelectronics, and Texas Instruments.

Bluetooth represents a large potential customer base for SiGe technology, as developers continue to chase the Bluetooth holy grail of a $5.00 transceiver. The hope of achieving that cost goal may be somewhat diminished by the issue of how to upgrade the Bluetooth standard. The existing Bluetooth 1.1 standard supports a data rate of 1 Mb/s—more than adequate for the interpretation of Bluetooth as a wireless cable replacement. But to compete with wireless network standards, such as the IEEE 802.11a/b/g standards which support data rates from 11 to 54 Mb/s, the Bluetooth Special Interest Group (SIG) is debating the form of Radio 2, the radio specification for the new Bluetooth 2.0 specification. Debate centers on whether to be satisfied with a data rate of 2 Mb/s and maintain the same basic Bluetooth radio architecture as version 1.1, or to adopt a new radio architecture for the benefit of increased data rates (to 10 Mb/s). Of course, the higher-data-rate solution would likely wipe out any chance for the $5.00 Bluetooth radio.

Established players in Bluetooth, such as Silicon Wave (San Diego, CA), recognize that Bluetooth embedded into cellular telephones may represent the largest single market for the 2.4-GHz wireless connectivity standard. The firm recently announced its second-generation (2G) chip set, with emphasis on supporting embedding solutions for cellular telephones, including code-division-multiple-access (CDMA)-compatible and Global System for Mobile Communications (GSM)-compatible radio modems. The devices incorporate direct-con-

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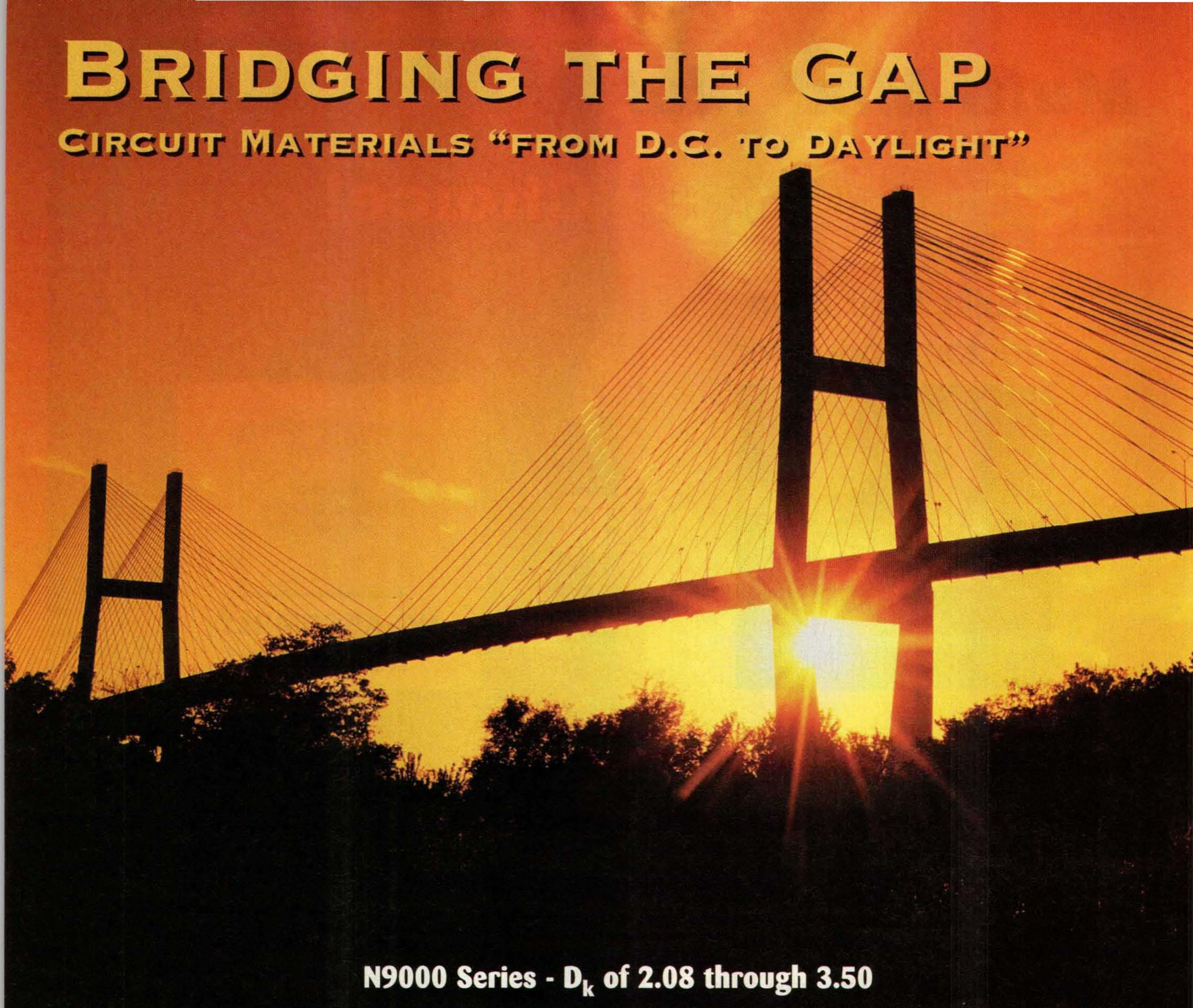


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The topic of TH3B is "Biological Effects and Medical Applications." Chaired and co-chaired by Vorst and Rajeev Bansal, respectively, Mohammad-Reza Tofighi *et al.*, of Drexel University, will cover the "Study of the Activity of Neurological Cell Solutions Using Complex Permittivity Measurement."

C. Wang and R.V. Snyder will serve as the chair and co-chair, respectively, for the TH3C session "Waveguide and Planar Filter Structures." M.A. El Sabbagh *et al.*, of the University of Maryland, will discuss the paper "Full-Wave Optimization of Stripline Tapped-In Ridge Waveguide Bandpass Filters."

"Special Session on Wide Bandgap Devices and their Application in High-Power Circuits" is session TH3D. It is chaired by Kevin Webb and co-chaired by Scott Sheppard. Invited author S.C. Binari *et al.*, of the Naval Research Laboratory, will cover "Trapping Effects in Wide-Bandgap Microwave FETs."

During session TH3E on Microwave Measurements II," G. Carchon *et al.*, of the IMEC division of MCP-HDIP, will give the paper, "Compensating Differences Between Measurement and Calibration Wafer In Probe-Tip Calibrations." The session's chair is A. Ferrero and co-chair is Larry Dunleavy.

D. Choudhury and J.C. Wiltse will be the chair and co-chair, respectively, of the TH4A session "W-Band Transceiver Components and Applications." A. Tessmann *et al.*, of the Fraunhofer Institute for Applied Solid State Physics, will talk about "A 94-GHz Single-Chip FMCW Radar Module For Commercial Sensor Applications."

Session TH4B focuses on "Frequency-Domain Techniques." Chaired by R. Sorrentino and co-chaired by A. Gopinath, Y. Liu *et al.*, of the University of Waterloo, will present the paper "Simulation of Resonant Modes of Rectangular DR in MIC Environment Using MPIE-MOM With Combined Entire-Domain and Subdomain Basis Functions."

"Special Session on Optical Processing of Antenna Signals" (session TH4D) is chaired and co-chaired by Minasian and Ed Rezek, respectively.

## Eyeing The Potential (cont'd)

*continued from page 44*

version techniques to reduce component count and cost, along with Si-on-insulator (SOI) technology for lower power consumption.

If the Bluetooth SIG aims at higher data rates, they will abandon the original concept of Bluetooth as a "cable replacement," and will invite further comparisons to (and competition from) wireless local-area networks (WLANs). Some firms, such as Eleven Engineering, Inc. (Edmonton, Alberta, Canada), have already seized on the opportunities for low-cost links in the 2.4 GHz. The firm, which manufactures the "Spike" short-range link, is a low-power (0.75-W transmit power) solution operating in the 900- and 2400-MHz unlicensed bands. It has already been licensed into Microsoft's XBox video-game system, and stands as a strong competitor to Bluetooth for other gaming and home-connectivity applications. The Spike link combines frequency hopping (60 hops/s) and direct-sequence-spread-spectrum (DSSS) techniques, operates under the control of a proprietary 50-MIPS microcontroller. The system has a range of up to 50 m and data rates to 844 kb/s.

Meanwhile, the WLAN application area appears strong and poised for rapid growth. Complete solutions for 5-GHz, 54-Mb/s 802.11a WLAN systems are available from Intersil and Systemonic, while a large number of suppliers offer solutions for the original 2.4-GHz, 11-Mb/s 802.11b WLAN standard. Resonext Communications (San Jose, CA) recently announced an all-CMOS two-chip solution for 802.11a 5-GHz WLANs using a zero-intermediate-frequency (IF) architecture to eliminate the need for surface-acoustic-wave (SAW) filters. The chip set requires in addition a PA, a trans-

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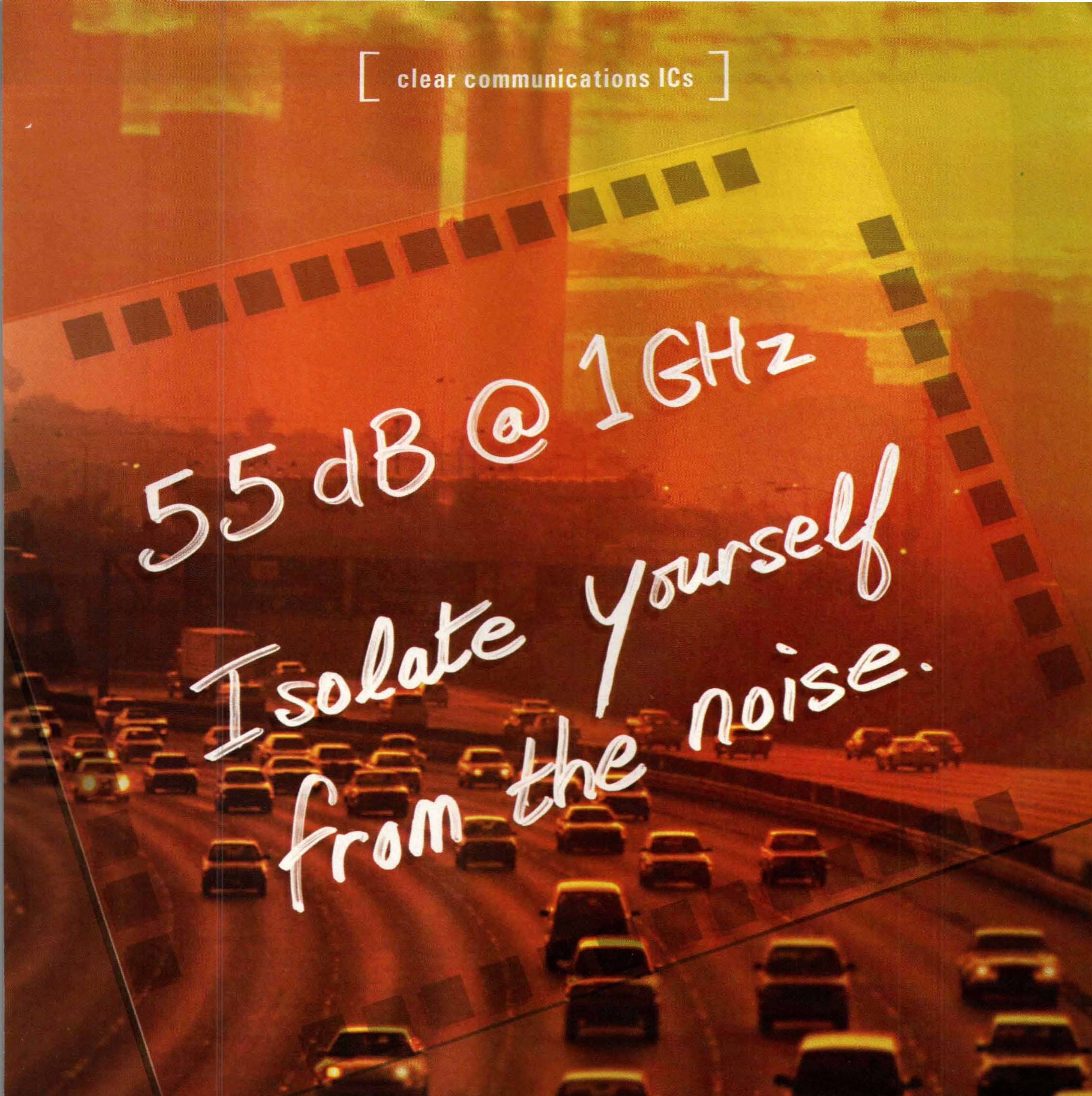


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| PE4237 | DC–4000 | 50 | 30 | 0.46 | 44 | 6L MLPM |
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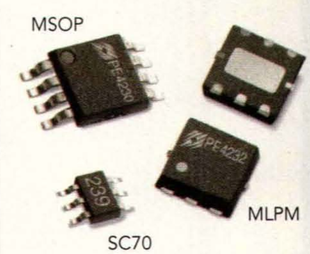
| PE4246 | DC–5000 | 80 | 30 | 0.75 | 55 | 6L MLPM |

**Switches**

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## Eyeing The Potential Of Emerging Technologies (cont'd)

*continued from page 48*

mit/receive (T/R) diversity-antenna switch, a bandpass filter, and a crystal resonator.

What could drive the widespread acceptance of 802.11a is a current movement for "global harmonization" of the WLAN spectrum between 5 and 6 GHz between the US and Europe, to allow European HiperLAN-2 WLANs and 802.11a WLANs to work together. Since the band from 5.470 to 5.725 GHz is not allocated for WLAN use in the US, the Wireless Ethernet Compatibility Alliance (WECA), an industry body for 802.11 WLANs, has formed a 5-GHz spectrum committee to propose new 802.11a WLAN frequency allocations to the Federal Communications Commission (FCC).

What of the quest for solid-state power? High-power devices for cellular applications are still dominated by laterally-diffused-metal-oxide-semiconductor (LDMOS) technology and companies such as Xemod and UltraRF have recently introduced devices to improve the linearity performance. Ericsson Microelectronics (Kista, Sweden) has experimented with a new LDMOS transistor with a dual-layer extended-drain region. The design is aimed at shielding the active gate region from high voltages.

However, wide-bandgap technologies, using Ga-nitride (GaN) or Si carbide (SiC) semiconductor materials may eventually challenge LDMOS. Nitronex Corp. (Raleigh, NC), for example, is currently growing GaN devices on 4- and 6-in. (10.16- and 15.24-cm) Si wafers. The company, started by graduates of North Carolina State University, has developed a proprietary-crystal growth process that significantly reduces the number of defects in the GaN crystals and is working on a discrete power transistor based on a HEMT structure. The company's CEO, Bob Lynch, notes that the power density of GaN is approximately six times that of Si, supporting several-hundred-watt devices with extremely linear and efficient output power at relatively high impedance levels, simplifying the matching circuitry used with the devices.

Cree, Inc. (Durham, NC) has been pursuing high-power SiC processes for several years, and has introduced several moderate-power transistors based on the material. In addition, military

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Pablo Monteagudo *et al.*, of the Universidad Politecnica de Valencia will discuss "Optimization of an Optical System Based on a Chirped Fiber Bragg Grating for Driving Phased-Array Antennas."

Session TH4E is titled "Superconducting Components and Technology," and includes a paper by G. Tsuzuki *et al.*, of Conductus, Inc., covering "Ultra-Selective 22-Pole, 10-Transmission Zero Superconducting Bandpass Filter Surpasses 50-Pole Chebyshev Rejection."



## Eyeing The Potential (cont'd)

*continued from page 52*

suppliers, such as Northrop Grumman (Baltimore, MD), for many years have evaluated the potential of novel structures and processes such as GaN and SiC for high-power semiconductors for military applications.

An emerging technology that may capture some applications handled by more traditional wireless technologies is often referred to as the "carrierless radio" ultrawideband (UWB) technology. In an UWB Tx, low-power signals are spread across a wide swatch of bandwidth and then detected and despread at the Rx. The levels of these transmitted signals is often much lower than the levels of what the US FCC refers to as "unintentional emitters." Still, the FCC revised its rules for wireless devices and approved deployment of UWB devices with much caution, fearing interference of existing systems, such as Global Positioning System (GPS). The FCC noted that initial UWB deployment would be limited to public-safety applications, such as through-wall imaging systems and ground-penetrating radars. The FCC also approved the use of UWB technology for WLANs and vehicle collision-avoidance systems. To avoid interference with GPS, UWB devices must operate above 3.1 GHz and must achieve spurious suppression of at least 34 dB in the 1.6-GHz GPS band.

Although the military has reservations about UWB technology due to its potential to interfere with existing systems, such as GPS, the technology also holds promise for ground-penetrating radars (which could be applied in the war in Afghanistan), since the image resolution is proportional to the bandwidth. Deeper ground penetration with UWB ground-penetrating radars is achieved by the use of

*continued on page 56*

## MTT-S PRODUCTS

### Inductors Suit Wireless Applications

A FAMILY OF RF surface-mount inductors is suitable for the 800-MHz-to-3.4-GHz range. Available with inductance values from 1 to 1200 nH, the inductors are designed for operating temperatures from −40 to 125°C. Traditional Electronic Industries Alliance (EIA) case sizes are 0402, 0603, 0805, 1008, and 1206. The inductor com-



## Eyeing The Potential (cont'd)

*continued from page 54*

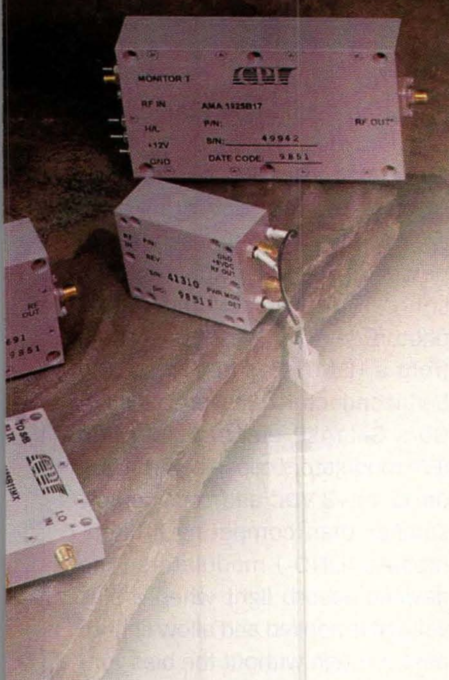
lower frequencies, down to approximately 50 MHz. Commercially, companies such as Time Domain (Huntsville, AZ) and XtremeSpectrum (Vienna, VA) are evaluating the potential of UWB technology for wireless applications. Time Domain has patented UWB technology that integrates radar, communications, and tracking capabilities on a single chip set, while XtremeSpectrum is evaluating a number of applications for UWB chips, including indoor wireless networks, digital cameras, and video recorders.

This year may also see the growth of 40-Gb/s (OC-768) fiber-optic technology, to feed consumers' insatiable need for data and faster Internet service. The 40G Collaborative is an industry group led by Photonex Corp., and including Corning, JDS Uniphase, Lightwave Microsystems, Microwave Concepts, New Focus, and LaserComm, that hopes to smooth the development and introduction of 40-Gb/s optical systems.

Metropolitan area networks (MANs) represent one of the largest areas for 40-Gb/s optical components and systems, and one where tunable lasers could play a key role in dense-wavelength-division-multiplexing (DWDM) optical networks. Tunable lasers could replace the currently used banks of lasers (for each wavelength) in these systems. Tunable lasers, based on indium-phosphate (InP) substrates, can make possible dynamic-wavelength routing and the emergence of reconfigurable optical networks. Even as commercial 40-Gb/s components and systems are being deployed, some researchers are exploring the possibility of 160-Gb/s systems.

*continued on page 58*

# Amplifiers



## 2-4 Week Delivery
## 2 Year Warranty

### Broadband, Small Signal

| Model Number | Frequency Range (Ghz) | Gain (dB Min) | Gain Flatness (±dB Max) | Noise Figure (dB Max) | VSWR Input Port Max | VSWR Output Port Max | Output Power @ 1dB CP (dBm Min) | DC Input Current Vdc:+12 (mA Typ) |
|---|---|---|---|---|---|---|---|---|
| CMA2080A1 | 2.0-8.0 | 30 | 1.5 | 6 | 2:1 | 2:1 | +15 | 200 |
| CMA20120A | 2.0-12.0 | 33 | 2.0 | 6 | 2:1 | 2:1 | +15 | 350 |
| CMA20180A | 2.0-18.0 | 34 | 2.0 | 6 | 2:1 | 2:1 | +18 | 450 |
| CMA60180A1 | 6.0-18.0 | 36 | 1.5 | 6 | 2:1 | 2:1 | +15 | 350 |
| CMA180265A | 18.0-26.5 | 30 | 1.5 | 6 | 2:1 | 2:1 | +16 | 400 |
| CMA265400A | 26.5-40.0 | 30 | 1.5 | 6 | 2:1 | 2:1 | +16 | 400 |

### Broadband, Low Noise

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CMA60180A2 | 6.0-18.0 | 30 | 1.5 | 3 | 2:1 | 2:1 | +10 | 200 |
| CMA180265A1 | 18.0-26.5 | 30 | 1 | 3 | 2:1 | 2:1 | +10 | 200 |
| CMA265400A1 | 26.5-40.0 | 28 | 1.5 | 3.5 | 2:1 | 2:1 | +10 | 200 |

### Medium Power

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CMA5964B10 | 5.9-6.4 | 40 | 1.0 | 8 | 1.5:1 | 1.5:1 | +33 | 1500 |
| CMA5971B1 | 5.9-7.1 | 20 | 1.0 | 10 | 1.8:1 | 1.8:1 | +33 | 1500 |
| CMA7185B2 | 7.1-8.5 | 20 | 1.0 | 10 | 1.8:1 | 1.8:1 | +33 | 1500 |
| CMA85125B1 | 8.5-12.5 | 30 | 1.5 | 8 | 2:1 | 2:1 | +35 | 3000 |
| CMA107117B2 | 10.7-11.7 | 20 | 1.0 | 10 | 1.8:1 | 1.8:1 | +33 | 2000 |
| CMA127132B | 12.7-13.2 | 40 | 1.0 | 5 | 1.8:1 | 1.8:1 | +34 | 4000 |
| CMA137145B | 13.7-14.5 | 45 | 1.0 | 6 | 1.5:1 | 1.8:1 | +33 | 1500 |
| CMA142153B6 | 14.2-15.3 | 15 | 1.0 | 8 | 1.5:1 | 1.8:1 | +30 | 1000 |
| CMA177197B15 | 17.7-19.7 | 35 | 1.0 | 8 | 1.5:1 | 2:1 | +30 | 1100 |
| CMA181186B17 | 18.1-18.6 | 34 | 0.5 | 10 | 1.5:1 | 1.5:1 | +33 | 3000 |
| CMA200230B1 | 20.0-23.0 | 10 | 1.0 | 12 | 1.5:1 | 2:1 | +30 | 1000 |
| CMA295297B1 | 29.5-29.7 | 20 | 0.3 | 10 | 1.5:1 | 1.8:1 | +30 | 1000 |

### High Power

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CMA1616B | 1.6-1.68 | 45 | 0.25 | 10 | 2:1 | 2;1 | +43 | 8500 |
| CMA4450B27 | 4.4-5.0 | 40 | 1.0 | 8 | 1.5:1 | 1.5:1 | +43 | 11000 |
| CMA5964B40 | 5.9-6.4 | 40 | 1.0 | 8 | 1.5:1 | 1.5:1 | +43 | 12000 |
| CMA127132B7 | 12.7-13.2 | 40 | 1.0 | 8 | 1.5:1 | 1.5:1 | +43 | 20000 |
| CMA137145B19 | 13.7-14.5 | 53 | 1.0 | 6 | 1.5:1 | 1.5:1 | +43 | 22000 |

### TWT/KPA Drivers, Linearized Gain Control

| Model Number | Frequency Range (Ghz) | Gain (dB Min) | Gain Flatness (±dB Max) | Noise Figure (dB Max) @ 0 Gain Control | VSWR In/Out Max | Gain Control (dB Max) | Output Power @ 1dB CP (dBm Min) | DC Input Current Vdc:+12 (mA Typ) |
|---|---|---|---|---|---|---|---|---|
| CMA5866A13 | 5.8-6.6 | 30 | 1.0 | 7 | 1.4:1/1.3:1 | 25 | +13 | 260 |
| CMA7984A1 | 7.9-8.4 | 30 | 1.0 | 7 | 1.4:1/1.3:1 | 25 | +13 | 260 |
| CMA127145A6 | 12.7-14.5 | 35 | 1.5 | 7 | 1.4:1/1.3:1 | 25 | +18 | 500 |
| CMA173184A8 | 17.3-18.4 | 38 | 1.0 | 7 | 1.4:1/1.3:1 | 25 | +20 | 500 |
| CMA270310A4W/G | 27.0-31.0 | 20 | 1.0 | 10 | 1.5:1/2.0:1 | 25 | +20 | 500 |

Note: Gain control voltage range is 0 to +10 Vdc (Maximum gain @ +10 Vdc)

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**● Enter NO. 75 at www.mwrf.com**

## Laser Diode Illuminates 10-Gb/s Optical Networks

A 10-GB/S OPTICAL-NETWORKING laser-diode module enables conversion of



## Eyeing The Potential (cont'd)

*continued from page 56*

At the device level, researchers at the Toshiba Cambridge Research Laboratory (Cambridge, England) recently announced a single-photon source based on a HEMT structure, operating with approximately one-thousandth the power of a conventional optical source. A corresponding single-photon detector was also formed from a HEMT structure. Also, Oki Semiconductor released their 40-Gb/s GaInAsP electroabsorption (EA) modulators capable of running on +2 to +3 VDC and considerably smaller than competing lithium-niobate ($LiNO_3$) modulators. The devices absorb light when a bias voltage is applied and allow light to pass through without the bias voltage, turning the laser on and off to create signal pulses.

In a similar vein, device researchers are also exploring the use of nanotechnology to possibly replace conventional transistors. In this field, individual atoms are used to assemble a desired structure. Self-assembly techniques involve guiding atoms to grow into those desired structures. Organic electronic designs involve the use of organic molecules as switching devices. Carbon (C) nanotubes also show great potential for replacing conventional transistors. Si nanowires have been assembled in HP Labs that are only six atoms across, overlaid in a grid pattern with one molecule in between.

Microelectromechanical systems (MEMS) are practical examples of nanotechnology, and represent a multibillion-dollar future market for electronic devices. A MEMS device can include moving parts, in effect micromachines, to form such RF and microwave devices as low-power relays and switches or optical switching devices.

electric signals to optical signals in medium-to-long-distance 10-Gb/s optical-fiber networks. This 1.55-μm wavelength distributed-feedback (DFB) laser diode is a high-speed, high-capacity light source that is suitable for optical networking. It is integrated with an electroabsorption (EA) modulator that uses a reverse bias for high-speed modulation.

**Fujitsu Compound Semiconductor, Inc., 2355 Zanker Rd., San Jose, CA 95131; (408) 232-9500, FAX: (408) 428-9111, Internet: www.fqd.fujitsu.com.**

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## HBT Amps Cover 1.7 To 2.8 GHz

A PAIR OF heterojunction-bipolar-transistor (HBT) medium-power monolithic-microwave-integrated-circuit (MMIC) amplifiers operates from 1.7 to 2.8 GHz with up to +27-dBm output power. Offering +40-dBm output third-order intercept point (IP3) from a single supply voltage, the HMC413QS16G is suitable for a linear power-amplifier (PA) driver in cellular, personal-communications-services (PCS), or third-generation (3G) base-station and repeater transmitters (Txs). The HMC413QS16G provides 22-dB gain and +30-dBm saturated power at a power-added efficiency (PAE) of 42 percent from a +5-VDC supply across the 1.7-to-2.3-GHz range.

**Hittite Microwave Corp., 12 Elizabeth Dr., Chelmsford, MA 01824; (978) 250-3343, FAX: (978) 250-3373, Internet: www.hittite.com.**

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## Switches Target DC To 65 GHz

A LINE OF frequency switches spans the DC-to-65-GHz range. With 1.4-dB maximum insertion loss, VSWR is 1.9:1 and minimum isolation is 50 dB. The switches also support 50-Ω impedance and 15-ms maximum switching time.They work with 1.85-mm (V-compatible) connectors and weigh 2 oz. Failsafe latching includes +12 VDC at 250-mA nominal current, +28 VDC at 140 mA, +12 VDC at 120 mA, and +28 VDC at 60 mA.

**RLC Electronics, Inc., 83 Radio Circle, Mount Kisco, NY 10549; (914) 241-1334, FAX: (914) 241-1753, Internet: www.rlcelectronics.com, e-mail: sales@rlcelectronics.com.**

● **Enter NO. 78 at www.mwrf.com**

## Front Ends Serve AMPS and PCS

THE RF2496 AND RF2498 are triband, quad-mode, Global Posi-

tioning System (GPS)-capable front ends that include receive-path functionality for code-division-multiple-access (CDMA) cellular applications. The RF2496 is designed for two-state gain-control solutions using a single control line, while the RF2498 is suitable for two control lines for three-state gain-control designs. The devices include an integrated transmitter (Tx) local-oscillator (LO) buffer and an integrated divide-by-two prescaler, which supports the use of a single PCS or dual-band voltage-controlled oscillator (VCO) for CDMA/AMPS operation. Both front ends are available in a 5 × 5-mm leadless plastic packages. P&A: $1.70 (10,000 qty.).
**RF Micro Devices, Inc., 7628 Thorndike Rd., Greensboro, NC 27409; (336) 664-1233, FAX: (336) 664-0454, Internet: www.rfmd.com.**
● **Enter NO. 79 at www.mwrf.com**

## PA Boasts 20-W P1dB Rating

THE MODEL PFM21020 is a high-power, 50-Ω RF power-amplifier (PA) module designed specifically to meet the linearity requirements of third-generation (3G) wireless-infrastructure systems. Rated at 20-W P1dB output power, the module has an 80-MHz bandwidth and maintains a gain flatness of better than 0.25 dB versus frequency of a baseplate temperature range of −10 to +90°C. The unit is highly linear, with typical two-tone intermodulation (IM) products of −40 dBc at 10-W peak-envelope power. **UltraRF, 160 Gibraltar Ct., Sunnyvale, CA 94089; (408) 745-5700, Internet: www.ultrarf.com.**
● **Enter NO. 80 at www.mwrf.com**

## RF ICs Target Cellular Applications

MODELS SPA-2118 AND SPA-2318 are linear power-amplifier (PA) RF integrated circuits (RF ICs) that offer 32-dB gain at 900 MHz and 23-dB gain at 1.9 and 2.1 GHz. These gallium-arsenide (GaAs) heterojunction-bipolar-transistor (HBT) devices cover the 850-, 1950-, and 2150-MHz frequency bands and perform as driver amplifiers for wireless-infrastructure equipment. The devices offer typical third-order intercept point (IP3) of +47 to +48 dBm and an IS-95 channel power of +23 to +24 dBm and wideband-code-division-multiple-access (WCDMA) channel power of +21.5 dBm at −45-dBc adjacent-channel power (ACP). Housed in standard surface-mount SOIC-8 plastic packages with backside metallization, the amplifiers are fabricated using state-of-the-art, high-performance GaAs semiconductor process technology. P&A: $9.90 (50,000 qty.).
**Sirenza Microdevices, Inc., 726 Palomar Ave., Sunnyvale, CA 94089; (800) 764-6642, (408) 616-5400, FAX: (408) 739-0970, e-mail: info@sirenza.com, Internet: www.sirenza.com.**
● **Enter NO. 81 at www.mwrf.com**

**Mike Snyder** has been President of KDI (Whippany, NJ) since 1995, which was renamed to MCE/KDI Integrated Products (Whippany, NJ) following its acquisition by MCE Companies in 1996. KDI's heritage stems from Engelmann Microwave and Pyrofilm, which were established in 1961 and 1957, respectively. He was deeply involved with the decision to reposition the company to exploit opportunities in the increasingly global wireless marketplace. With only a few exceptions, MCE/KDI Integrated Products no longer offers a line of single-function passive microwave components. Instead, the focus is on delivering solutions that are tailored to solve problems unique to the needs of a single customer or market segment. The viability of this strategy is evident in the fact that while the wireless industry as a whole declined in 2001, KDI did not.

# An Interview with KDI's Mike Snyder

**MRF:** *What led you to the decision to radically change KDI's business model?*

**Snyder:** For most of its history, KDI made traditional single-function microwave components. But our customers increasingly wanted us to provide more complete solutions to their problems, rather than just a small part of them. We were also critically aware of the trend toward vendor reduction by the system integrators. Our customers were looking for partners that could take the burden of component integration from their shoulders by providing not just a component such as a power divider, but rather a more complete network with additional functions as well. The trend of system integrators was clearly toward having fewer vendors with multidisciplinary skills. It appeared to us that a brighter future awaited companies that could create high-performance packaged solutions, and since we had already developed a high level of competency in integrating multiple functions, we chose to move in this direction.

**MRF:** *How did this impact your core business which, at that time, was a primarily single-function product?*

**Snyder:** At the time we committed the company to its new direction, one of our first tasks was to examine our customer base which, at that time, numbered in the thousands. Like most microwave companies, we had a huge list of so-called standard parts, a huge catalog, and a 40-plus-year history of creating special variations for specific needs. By almost completely eliminating catalog products and one-off specials with little likelihood of volume production, our customer base shrank significantly and rapidly. We went almost overnight from a company that served almost everyone's needs to one that focused on a much smaller number of more "appealing" opportunities. Instead of spreading our engineering resources over a wide base, we instead could concentrate on fewer opportunities that held the promise of greater return.

**MRF:** *This must have created more than a little anxiety.*

**Snyder:** No question about that. We now had a different type of backlog. We lost our security blanket so to speak, the broad mix of small orders that we had always counted on. It was replaced with a much smaller number of larger orders for vastly more complex subsystems. Changing the company's direction required us to turn down the type of business upon which the company had been built. The process of pruning our customer base was pretty painful. We had to learn to say no. In the end, we reduced our customer base by about 70 percent. Of course, we couldn't simply turn away loyal customers who had relied on KDI for many years, so we continued to meet their needs and assisted them in locating new sources while making it clear that soon we would no longer be in that business. We still serve some of these companies, but their number has declined dramatically.

**MRF:** *What internal changes occurred due to the transition?*

**Snyder:** We split the company into two divisions, so each could focus on what it does best—MCE/KDI Integrated Products and MCE/KDI Resis-

tors. There were and continue to be wide-ranging positive effects. First, we were able to significantly reduce our inventory, since we were no longer making a huge number of low-volume products. For our designers, there were new challenges, such as learning entirely new areas of microwave technology as well as digital technology and mastering techniques for integrating them both.

**MRF:** *You also chose to outsource the manufacturing of most of your commercial products to contract assemblers. With such a long history of manufacturing, how did you come to this decision?*

**Snyder:** It was actually a relatively simple decision. There are a large number of truly outstanding contract manufacturers throughout the world that provide a compelling alternative to making everything yourself, especially in light of the far more international scope of RF and microwave opportunities today. In our experience, you lose nothing by relying on a highly competent contract assembler, and you gain so much in return in terms of reduced cost, complexity, and overhead. We still do all the engineering and rigidly control quality and consistency. However, we still manufacture nearly all of our military products ourselves, because of the unique nature of this market. The military environment requires the skills that we have developed over many years that are very difficult to outsource.

**MRF:** *What types of products have resulted from this particular change in direction?*

**Snyder:** One of the best examples of our integrated systems and subsystems is a bandpass filter/LNA that we designed for CDMA base stations. This product allows reliable communication to be established with mobiles that were previously at or below the minimum level required to provide reliable communication. The system provides sharp rejection of unwanted signals from adjacent bands and improves system noise figure by as much as 2.8 dB. As a result, the base station can command the mobile to reduce its output power by about 8 dB, since maximum output is no longer needed to maintain the link. So the battery life of the mobile increases noticeably.

The system has spent a considerable amount of time in field trials with major service providers and it has shown the ability to significantly reduce the number of dropped calls, increase average call length, and prolong mobile battery life. So for much less cost, less complexity, and greater reliability than a superconducting filter that requires cooling, this system achieves similar results. One of our earliest successes was with a built-in cell-site test system, which is in service in thousands of locations throughout the US cellular network. It places a call through a live cell site at regular intervals to monitor the integrity of the transmission chain.

> ***We went almost overnight from a company that served almost everyone's needs to one that focused on a much smaller number of more "appealing" opportunities.***

**MRF:** *In 1996, KDI/Triangle Electronics was acquired by MCE Companies, Inc., which was founded by John Smucker. What has been the effect of the acquisition?*

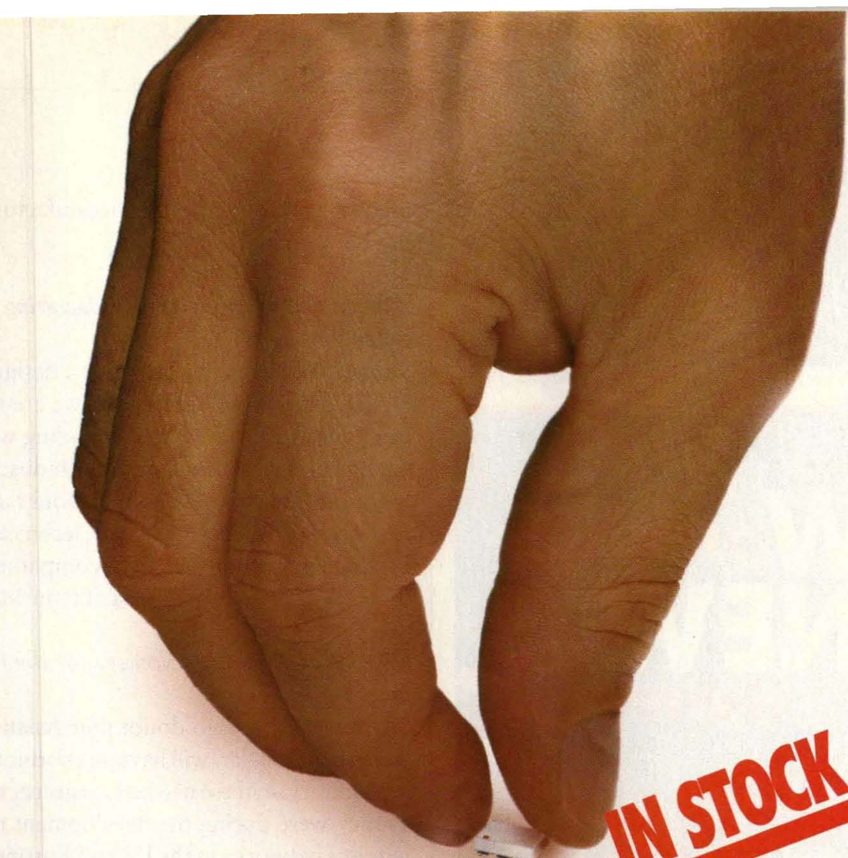
**Snyder:** To serve many of the markets we believe are critical to our future, we need significant resources, and our place as the largest component of a diversified microwave-technology company provides them. We can now address market opportunities that are simply not available to smaller companies, because system integrators continue to move toward having fewer vendors that each contribute a greater number of capabilities. There is also considerable synergy between the MCE companies, which include Inmet, Metelics DML Microwave, Weinschel, and MCE Technologies in Nanjing, China. Each enterprise routinely draws on the expertise of the others. We have established a corporate-wide technology review board that allows everyone to be well-informed about new developments and we have established a design facility in Germantown, MD, that is dedicated to development of new KDI products.

**MRF:** *Are many of the company's opportunities in China?*

**Snyder:** China has always represented an enormous potential opportunity for the microwave industry, but until recently there have been too many political and cultural roadblocks to success. However, this is rapidly changing. China is now a member of the World Trade Organization. The opportunities there have never been greater or more achievable. However, there are significant barriers to entry that only companies with a genuine commitment and considerable resources will be able to hurdle. The resources of MCE are making it possible for KDI to be real player in this market.

**MRF:** *What are the most formidable of these entry barriers?*

**Snyder:** To serve the largest wireless-system integrators addressing the Chinese market, it is becoming absolutely essential for subcontractor manufacturers to have facilities in the local market. China, in particular, has made it abundantly clear that wireless products sold there must have significant local content. This requires system integrators to establish design and manufacturing facilities in China. These integrators have made it equally clear that the suppliers they retain will be the ones that also have manufacturing facilities in China. In other words, they have told their suppliers that unless they have a man-



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|---|---|---|---|---|---|---|---|
| ADE-1L | +3 | 2-500 | 5.2 | 55 | 16 | 3 | 3.95 |
| ADE-3L | +3 | 0.2-400 | 5.3 | 47 | 10 | 4 | 4.25 |
| ADEX-10L | +4 | 10-1000 | 7.2 | 60 | 16 | 3 | 2.95 |
| ADE-1 | +7 | 0.5-500 | 5.0 | 55 | 15 | 4 | 1.99▲ |
| ADE-1ASK | +7 | 2-600 | 5.3 | 50 | 16 | 3 | 3.95 |
| ADE-2ASK | +7 | 1-1000 | 5.4 | 45 | 12 | 3 | 4.25 |
| ADE-6 | +7 | 0.05-250 | 4.6 | 40 | 10 | 5 | 4.95 |
| ADEX-10 | +7 | 10-1000 | 6.8 | 60 | 16 | 3 | 2.95 |
| ADE-12 | +7 | 50-1000 | 7.0 | 35 | 17 | 2 | 2.95 |
| ADE-4 | +7 | 200-1000 | 6.8 | 53 | 15 | 3 | 4.25 |
| ADE-14 | +7 | 800-1000 | 7.4 | 32 | 17 | 2 | 3.25 |
| ADE-901 | +7 | 800-1000 | 5.9 | 32 | 13 | 3 | 2.95 |
| ADE-5 | +7 | 5-1500 | 6.6 | 40 | 15 | 3 | 3.45 |
| ADE-5X | +7 | 5-1500 | 6.2 | 33 | 8 | 3 | 2.95 |
| ADE-13 | +7 | 50-1600 | 8.1 | 40 | 11 | 2 | 3.10 |
| ADE-11X | +7 | 10-2000 | 7.1 | 36 | 9 | 3 | 1.99▲ |
| ADE-20 | +7 | 1500-2000 | 5.4 | 31 | 14 | 3 | 4.95 |
| ADE-18 | +7 | 1700-2500 | 4.9 | 27 | 10 | 3 | 3.45 |
| ADE-3GL | +7 | 2100-2600 | 6.0 | 34 | 17 | 2 | 4.95 |
| ADE-3G | +7 | 2300-2700 | 5.6 | 36 | 13 | 3 | 3.45 |
| ADE-28 | +7 | 1500-2800 | 5.1 | 30 | 8 | 3 | 5.95 |
| ADE-30 | +7 | 200-3000 | 4.5 | 35 | 14 | 3 | 6.95 |
| ADE-32 | +7 | 2500-3200 | 5.4 | 29 | 15 | 3 | 6.95 |
| ADE-35 | +7 | 1600-3500 | 6.3 | 25 | 11 | 3 | 4.95 |
| ADE-18W | +7 | 1750-3500 | 5.4 | 33 | 11 | 3 | 3.95 |
| ADE-30W | +7 | 300-4000 | 6.8 | 35 | 12 | 3 | 8.95 |
| ADE-1LH | +10 | 0.5-500 | 5.0 | 55 | 15 | 4 | 2.99 |
| ADE-1LHW | +10 | 2-750 | 5.3 | 52 | 15 | 3 | 4.95 |
| ADE-1MH | +13 | 2-500 | 5.2 | 50 | 17 | 3 | 5.95 |
| ADE-1MHW | +13 | 0.5-600 | 5.2 | 53 | 17 | 4 | 6.45 |
| ADE-10MH | +13 | 800-1000 | 7.0 | 34 | 26 | 4 | 6.95 |
| ADE-12MH | +13 | 10-1200 | 6.3 | 45 | 22 | 3 | 6.45 |
| ADE-25MH | +13 | 5-2500 | 6.9 | 34 | 18 | 3 | 6.95 |
| ADE-35MH | +13 | 5-3500 | 6.9 | 33 | 18 | 3 | 9.95 |
| ADE-42MH | +13 | 5-4200 | 7.5 | 29 | 17 | 3 | 14.95 |
| ADE-1H | +17 | 0.5-500 | 5.3 | 52 | 23 | 4 | 4.95 |
| ADE-1HW | +17 | 5-750 | 6.0 | 48 | 26 | 3 | 6.45 |
| ADEX-10H | +17 | 10-1000 | 7.0 | 55 | 22 | 3 | 3.45 |
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***Protected by U.S. patent 6133525.** ▲*100 piece price.*

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ufacturing facility near their manufacturing facility, they will not be approved as a vendor.

**MRF:** *Is KDI establishing manufacturing facilities in China and other countries?*

**Snyder:** Yes. We currently have a design and manufacturing facility in Nanjing, China, and we are rapidly expanding its capabilities to address the exploding wireless market there. China has a wealth of extremely industrious, talented, highly educated technical people, and our facility is staffed almost exclusively by Chinese designers, technicians, and support staff. Products for all of the MCE companies will soon be made there. We have also had a facility in Mexico since 1998.

**MRF:** *What trends do you see for the future of the wireless marketplace?*

**Snyder:** We have no doubt that Asian markets, China and Korea in particular, will have an enormous impact on the wireless industry. In these markets, customer desires are clear, much as they were during the development of second-generation wireless networks in the US and Europe. The ability to serve these markets will increasingly require a genuine local presence with a demonstrable ability to design, manufacture, and service products in the local market. Without these capabilities, it is likely that US manufacturers will not be able to compete at all. We are devoting resources to ensure that KDI is in a position to capitalize on these opportunities. MRF

## Filters Target WLAN Applications

THE LTF1608L is a reflow-solderable series of multilayer ceramic lowpass filters that are manufactured with a proprietary ceramic material and process. The filter series operates over the –55 to +125°C temperature range. Designed for use in harmonic-rejection applications for cellular handsets, wireless PDAs, and IEEE 802.11b WLAN, the LTF1608L provides second- and third-harmonic attenuation levels of 35 and 25 dB, respectively at a maximum insertion loss of 0.5 dB. Impedance is 50 Ω, maximum ripple is 0.50 dB, and return loss is 14 dB across the series. Bandwidth ranges from ±12.5 to ±50.0 MHz. The units are housed in a 1.6 × 0.8 × 0.9-mm package.

**Toko America, Inc., 1250 Feehanville Dr., Mt. Prospect, IL 60056; (847) 297-0070, FAX: (847) 699-1194, e-mail: info@toko am.com., Internet: www.tokoam.com.**

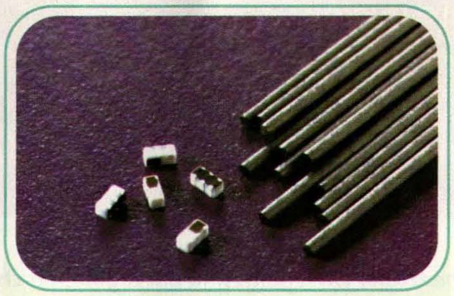
**●Enter No. 62 at www.mwrf.com**

## Synthesizers Are Suitable As PLDRO Replacements

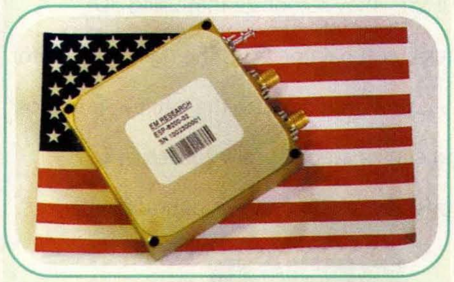
THE VCO-BASED ESP Series of phase-locked frequency synthesizers are suitable for use as low-cost replacements for PLDROs. Supplied as fixed-frequency or serially programmable precision phase-locked oscillators, the ESP Series products are design to cover the frequency range (in bands) from 50 MHz to 12 GHz. The synthesizers use internal or external frequency references and are supplied with internal regulators and buffer amplifiers. The ESP Series typically operate over the temperature range of –30 to +70°C. The Al housing measures 2.25 × 2.25 × 0.60 in. (5.72 × 5.72 × 1.52 cm) [excluding connectors] and can be hermetically sealed for use in military applications.

**EM Research, Inc., P.O. Box 1247, Verdi, NV 89439; (775) 345-2411, FAX: (775) 345-1030, e-mail: sales@emresearch.com, Internet: www.emresearch.com.**

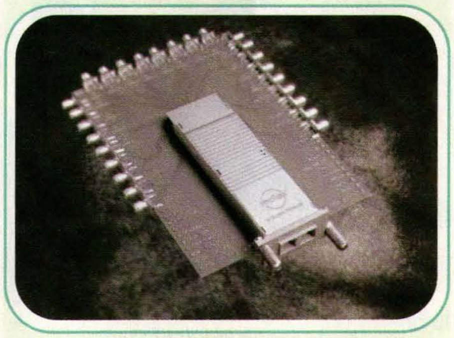
**●Enter No. 63 at www.mwrf.com**



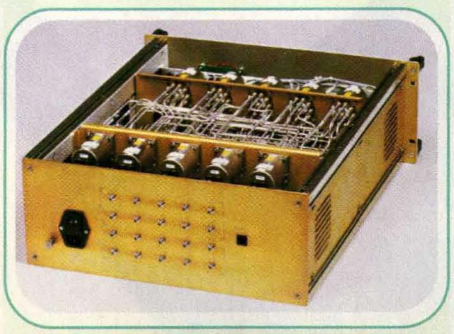
**TOKO AMERICA LTF1608L FILTERS**



**EM RESEARCH ESP SERIES SYNTHESIZERS**



**MOLEX, INC. WWDM TRANSCEIVERS**



**DOW-KEY MICROWAVE COAXIAL MATRICES**

## Transceiver Provides 10-Gb/s Data Throughput

THE MUXLINK™ LINE of WWDM transceivers are designed to meet the IEEE 802.3ae 10-Gb Ethernet 10GBASE-LX4 PMD standard. They are compliant with the XENPAK multisource agreement that uses the XAUI electrical interface. Each MuxLink transceiver has four 3.125-Gb/s DFB lasers, which are optically multiplexed to provide 10-Gb/s data throughput. The transceivers support up to 300-m transmission distance over installed multimode fiber. The module is hot pluggable and packaged in the industry-standard XENPAK form factor. The optical interface for XENPAK is a duplex SC connector.

**Molex Fiber Optics, 5224 Katrine Ave., Downers Grove, IL 60515; (800) 78-MOLEX, (630) 512-8787, Internet: www.molex.com.**

**●Enter No. 64 at www.mwrf.com**

## Matrices Integrate With Ethernet Networks

THE 4101-ENET IS a CANbus-based switch matrix equipped with a built-in Ethernet port that performs up to 18 GHz, and can be configured with up to 10 inputs and up to 10 outputs. From 12 to 18 GHz, insertion loss is 6 dB maximum and isolation is 50 dB minimum. VSWR is 1.4:1 from DC to 8 GHz, 1.6:1 from 8 to 12 GHz, and 1.8:1 from 12 to 18 GHz. Users can easily access this matrix from anywhere in the world through TCP/IP protocols on 10BaseT networks. Each unit is equipped with an LCD front-panel display and keypad for manual override and the Ethernet. The unit is housed in a 19-in. (48.26-cm) rack-mountable chassis. The enclosure and power supply is matched for EMI integrity. Connector options include N or BNC.

**Dow-Key Microwave Corp., 4822 McGrath St., Ventura, CA 93003-7718; (805) 650-0260, FAX: (805) 650-1734, Internet: www.dowkey.com.**

**●Enter No. 65 at www.mwrf.com**

# Aeroflex Acquires IFR Systems

IFR SYSTEMS (Wichita, KS) has announced that it has been acquired by Aeroflex, Inc. (Plainview, NY), a leading designer, developer, and manufacturer of microelectronics and automated testing solutions for the broadband-communications market. IFR is a leading designer and manufacturer of advanced wireless test solutions for communications, avionics, as well as general test-and-measurement applications. Valued at approximately $60 million in cash, the transaction includes the retirement of IFR Systems' bank indebtedness.

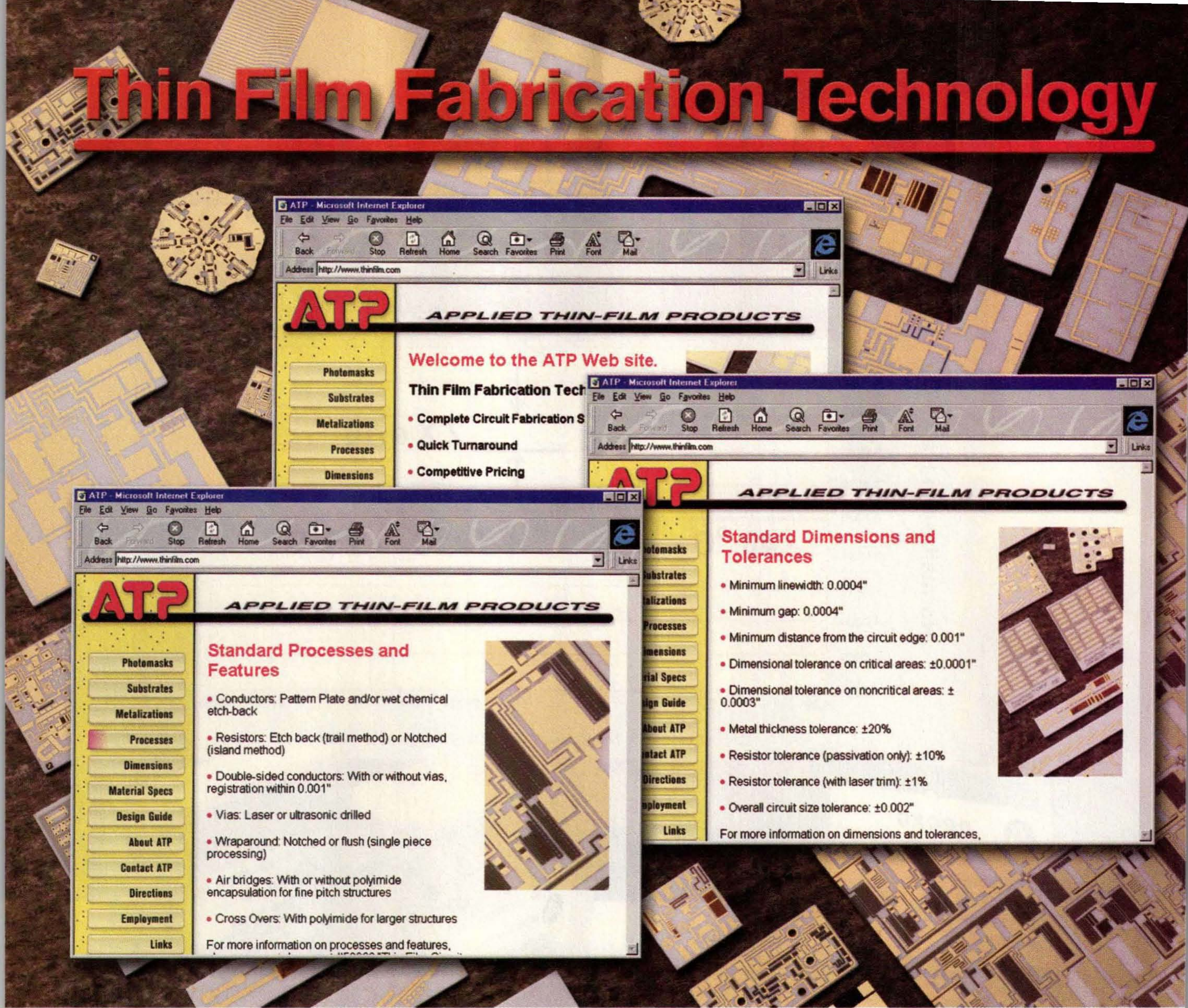
As part of the agreement, IFR's banks have agreed to accept $48.8 million as payment for all obligations, which is approximately $35 million less than the amount owed to them. IFR's banks have also agreed to forebear immediate collection of the loan until August 30th or the earlier termination of the proposed tender offer.

Jeffrey Bloomer, CEO and President of IFR Systems, said, "The company is undercapitalized and cash constrained. Our Board felt it was in the best interests of shareholders, employees, and lenders to approve this transaction."

Michael Gorin, President of Aeroflex, stated, "We at Aeroflex are pleased that IFR's Board of Directors and lending banks have unanimously endorsed the transaction. IFR's test-instrument and systems product line complements our test-solutions product line with a minimum of overlap and is expected to result in significant synergies in both sales and operating income. In addition, this transaction will significantly enhance our market presence in the UK, European, and Asia Pacific regions."

The agreement also states that Aeroflex will commence a cash tender offer for all outstanding shares of IFR Systems' common stock for $1.35 per share followed by a merger at the same per-share price. Aeroflex's common stock trades on the Nasdaq under the symbol "ARXX" and is included in the S&P SmallCap 600 index.

The Board of Directors at each company has approved the transaction and it is expected to be completed by the end of the second quarter of 2002. TM Capital Corp. served as financial advisor to IFR Systems in connection with this transaction. MRF

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## CONTRACTS

**Andrew Corp.**—Has entered into distribution agreements with Ericsson, Nokia, and Samsung. Under these agreements, Andrew will distribute a full line of OEM-branded accessories to all customers as well as new distribution channels. The Ericsson, Nokia, and Samsung accessory products will be packaged either in private label packaging for wireless service providers or in jointly branded packaging with Andrew's and the manufacturer's logo added.

**Fleet*Edge* Equipment Intelligence Systems**—Was awarded a contract by B&B Equipment Rentals of Lakeside, CA for the management of B&B's heavy equipment rental fleet. The Fleet*Edge* system uses wireless technology to enable companies in the construction, rental, and heavy equipment markets to reduce costs by using newly developed intelligence on their fleets.

**Edwards and Kelcey**—Acquired the engineering firm Aikenhead & Odom (A&O), which is located in Jacksonville, FL. A&O is a specialized engineering, design, and consulting firm serving public and private clients throughout Florida in transportation, utilities, private development, and environmental engineering.

**Exsil, Inc.**—Announced that its parent company, Rockwood Specialties, has acquired the business and assets of American Silicon Products, Inc. of Providence, RI. The acquisition became effective on March 1. American Silicon Products (ASP), a subsidiary of SEMX Corp., specializes in providing wafer polishing, refurbishing, and reclaiming services to the North American electronics industry.

**Aethercomm**—Awarded two new contracts. The first contract award is from Metric Systems Corp. of Fort Walton Beach, FL. Aethercomm has been contracted to design, develop, and manufacture 51 high-power, L-band PAs in support of Metric's Data Link Transmitter product line. The second contract is from the US Navy for 20 high-power, L-band PAs in support of the US Marine Corps' TPN30 Radar System. The TPN30 is a TACAN System that operates from 962 to 1215 MHz. Aethercomm's PA delivers more than 300 W of pulsed RF power across this band.

## FRESH STARTS

**Hittite Microwave Corp.**—Has opened a third international sales office, Hittite Microwave Asia Ltd., located in Seoul, Korea. This office will house a staff of sales engineers that will directly support Hittite's expanding Asian customer base in China, Japan, Korea, Malaysia, Singapore, and Taiwan. Thomas Hwang will lead the office as Asia-Pacific Branch Manager. He can be contacted by phone at (+82-2) 559-0638, by FAX at (+82-2) 559-0639, or by e-mail at hwang@hittite.com. The new office address is: POSCO Center Bldg., West Tower 11th Floor, 892 Daechi-dong, Kangnam-gu, Seoul, Korea 135-777.

**Hybrid Networks, Inc.**—Announced that Thales Broadcast & Multimedia will deploy Hybrid's base station and Wireless Broadband Routers™ (WBRs) to deliver fixed-broadband wireless service to residential and business customers in India. Thales Broadcast & Multimedia is supplying Indian service provider Nextage Broadband Ltd. with a complete system using a Thales Affinity Base Station, Hybrid's base station and WBRs, and REMEC's antennas and transceivers. The system will operate in the 2.8-to-2.9-GHz spectrum.

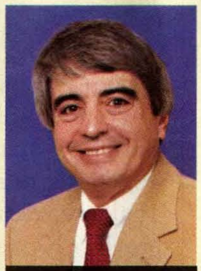
**Telemac Corp.**—Has established offices in Europe and Asia. Telemac's new Europe/Middle East/Africa (EMEA) sales and engineering headquarters is located near Cambridge, England. The EMEA offices house engineers, business-development executives, and support staff. Telemac's new Asia-Pacific sales office is located in Singapore. Telemac's Singapore base will accelerate Telemac's business-development efforts throughout Asia and the Pacific regions and will facilitate coordination of Telemac's representatives in Asia and Australia.

**Applied Innovation, Inc.**—Announced the implementation of a network operations center (NOC) for D&E Communications, a regional telephone and data service provider headquartered in Pennsylvania. The advanced operations center, located in Lancaster County, PA, provides out-of-band visibility and management to intelligent, revenue-generating elements in D&E Communications' network. As part of the implementation, Applied Innovation designed, installed, and tested a video-switching system to display NEweb, AIwatch, and other video outputs to four 42-in. (107-cm) display units, along with up to 100 PC monitors in the NOC.

**Agilent Technologies, Inc.**—Has adopted Agilent Advanced Design System (ADS) software to help accelerate its new product design work and expand its product line. ADS is EDA software for communications product design. ADS provides an integrated environment for communications system, RF subsystem, and circuit-level (RF IC/MMIC, RF/microwave board and module) schematic and layout design entry and simulation.

**RF Micro Devices, Inc.**—Opened a sales and customer-support office located at A-2, 9F, No. 216, Sec. 2, Tun-Hwa S. Road, Taipei, Taiwan, R.O.C. The Taiwan office includes a customer-development lab specifically outfitted for WLAN and GSM handset development.

**TECOM Industries, Inc.**—Has relocated and consolidated three of their production plants to a newer and larger facility. The two-story facility is 66,000 sq. ft., providing an additional 20,000-sq.-ft. expansion dedicated to design, manufacturing, and testing while allowing for future growth in the wireless, defense, and SATCOM antenna product lines. The new contact information is: TECOM Industries, Inc., 375 Conejo Ridge Ave., Thousand Oaks, CA 91361, phone: (805) 267-0100, FAX: (805) 267-0181. MRF



CAPECI

## ITT Industries, Avionics Appoints Capeci

ITT Industries, Avionics of Clifton, NJ has appointed JOHN CAPECI as director of marketing. He comes to his current position at ITT from Teteboro, NJ-based Honeywell International, where he served as director of technology and systems engineering.

**Vitesse Semiconductor Corp.**—PHIL RICHARDS to vice president of sales for channels and partners; formerly senior director of Asia Sales for Sun Microsystems, Microelectronics Division. Also, SIEGMAR HAUSBERGER to director of sales for Europe, Africa, and the Middle East (EAM); formerly sales director for Central and South Europe at Conexant/Mindspeed Technologies. In addition, MITCHELL TANG to director of Asia/Pacific sales; formerly in charge of Asia/Pacific sales for AMCC's network-processor, traffic-management, and switch-fabric products.

**Avnet Electronics Marketing**—PHIL GALLAGHER to senior vice president for global business development; formerly president of Avnet Cilicon and Avnet RF & Microwave. In addition, HARLEY FELDBERG to president of Avnet Electronics Marketing Americas; formerly president of Avnet Electronics Marketing Asia. In addition, RAYMOND TSANG to president of Avnet Electronics Marketing Asia; formerly CEO of Sunrise Technologies.

**TÜV America, Inc.**—STEFAN P. BUTZ to president and CEO of TÜV's North American (NAFTA) operations; formerly director of corporate development at TÜV Süddeutschland Holding AG.

**Qualcomm, Inc.**—ANTHONY S. THORNLEY to president; remains as COO. Also, WILLIAM E. KEITEL to senior vice president and CFO; formerly corporate controller.

**LBA Group**—SYLVIA CASH to executive assistant to the CEO; formerly executive administrator at Group Design Associates.

**Filtel Microwave, Inc.**—CRAIG SUTTON to vice president of marketing and sales; formerly CEO of Filtran Microcircuits, Inc.

**Amphion Semiconductor Ltd.**—DANIEL V. HAUCK to president of Amphion Semiconductor, Inc., the wholly owned US subsidiary, and vice president of worldwide sales; formerly vice president of worldwide sales for BOPS.

**LPKF Laser & Electronics USA**—STEPHAN H. SCHMIDT to the board of directors, as well as being named vice president and secretary; remains as general manager.

**ITS Networks, Inc.**—GUSTAVO GOMEZ to president and CEO; previously founded OpenVia S.L.

GOMEZ

HILDRETH

**Hittite Microwave Corp.**—NORM HILDRETH to director of product development; formerly vice president of wireless products at Sirenza Microdevices. Also, RAYMOND T. PAVIO to business development manager for multichip modules; formerly engineering manager with M/A-COM's Semiconductor Business Unit.

**Instruments & Equipment Co. (I&E)**—GEORGIA A. LOMBARDI to vice president of sales for the OEM and Point-of-Sales Transaction Division; formerly director of system sales at Star Micronics America, Inc. MRF

## ▸ SHORT COURSES

**Fundamentals of Wireless Data Communications**
June 3-5 (Madison, WI)
University of Wisconsin
College of Engineering
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432 Lake St.
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e-mail: danbeck@epd.engr.wisc.edu

**Advanced Industrial Laser Welding**
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**Microwave Antenna Measurements Short Course: Far-Field, Near-Field, Compact Ranges and Anechoic Chambers**
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Shirley Lang
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e-mail: shirley.lang@csun.edu
Internet: www.ecs.csun.edu/~crs/mam/

## ▸ MEETINGS

**2002 IEEE MTT-S INT'L Microwave Symposium**
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2002 IMS Technical Program, 59th ARFTG Microwave Measurement Conference IMS2002 and RFIC Radio Frequency Integrated Circuits (RFIC) Symposium 2002
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**FiberComm**
June 4-6 (Munich, Germany)
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Kelly Arvisais
(312) 850-8202, FAX: (312) 829-3255
e-mail: karvisais@yourthoughtpartner.com
Internet: www.munichtradefairs.com

**Atlantic Design & Manufacturing Show**
June 4-6 (New York, NY)
Jacob K. Javitz Convention Center
655 W. 34th St.
New York, NY
c/o Cannon Communications LLC
11444 W. Olympic Blvd.
Los Angeles, CA 90064-1549
(310) 445-4200, FAX: (310) 996-9499
Internet: www.atldesignshow.com

**ARFTG 59th Microwave Measurements Conference**
Test, Measurement, and Characterization of High-Speed Digital Components and Systems
June 7 (Seattle, WA)
Washington State Trade and Convention Center
Alfry Riddle, Technical Program Chair
Macallan Consulting
1583 Pinewood Way
Milpitas, CA 95035
(408) 262-3575
e-mail: admin@macallanconsulting.com
Internet: www.arftg.org

**IMAPS ISRAEL 2002**
June 13 (On Sea, Israel)
Daniel Hotel, Herzelia
Sponsored by the International Microelectronics and Packaging Society (IMAPS of Israel)
General Chair: Uri Barneah, MicroAssembly Technologies Ltd.
e-mail: Ubarneah@inter.net.il
Internet: www.imaps.org

## ▸ CALL FOR PAPERS

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## Fractal Geometries Provide Foundations For Miniature Antennas

FRACTAL ANTENNAS HOLD GREAT PROMISE for miniaturization without loss of performance. Fractal geometries have been used to model complex natural objects, such as clouds and coastlines, as well as having space-filling properties that can be applied for the development of miniature antennas. Fractals are essentially complex shapes that are easy to define, supporting the use of contours that add the electrical length desired in an antenna, but without adding physical size. Authors John Gianvittorio and Yahya Rahmat-Samii from the Dept. of Electrical Engineering of the University of California at Los Angeles (Los Angeles, CA) explain how MOM can be applied to the modeling of fractal antennas and how practical fractal wire and loop antennas can be fabricated. The authors also explore the fabrication of fractal dipole antennas and fractal microstrip patch elements. See "Fractal Antennas: A Novel Antenna Miniaturization Technique, and Applications," *IEEE Antennas and Propagation Magazine,* February 2002, Vol. 44, No. 1, p. 20.

## Cofired Laminated Ceramic Package Integrates Antenna

CUTTING THE COSTS OF WIRELESS DESIGNS may be possible by applying an antenna design approach by Y.P. Zhang and M.A. Do of the Nanyang Technological University (Nanyang, Singapore). The researchers implemented a wideband antenna on a 40-pin cofired laminated ceramic package. The antenna, which is fabricated with deep-submicron CMOS technology, features better than 25-percent bandwidth at 3.45 GHz with gain of −2 dBi. See "Cofired Laminated Ceramic Package Antenna For Single-Chip Wireless Transceivers," *IEEE Microwave And Optical Technology Letters,* April 5, 2002, Vol. 33, No. 1, p. 15.

## Monolithic +1.5-VDC CMOS Synthesizer Switches Quickly At 900 MHz

FAST SYNTHESIZER SWITCHING SPEED is desirable in many modern communications systems designs. Since conventional PLL frequency synthesizers are limited in switching speed, researchers Chi-Wa Lo and Howard Cam Luong of the Dept. of Electronic and Electrical Engineering of the Hong Kong University of Science and Technology (Kowloon, Hong Kong) developed a new architecture for PLL synthesizers employing a switchable capacitor array to tune the synthesizer's output frequency and a dual-path loop filter for enhanced switching speed. The synthesizer was designed for use in GSM systems, supporting a frequency range of 865 to 890 MHz for a 70-MHz IF with 200-kHz resolution. The complete synthesizer system includes a fractional-N PLL synthesizer, an $\Sigma\Delta$ modulator, and a gain-and-offset-adjustment circuit. The PLL synthesizer consists of two I/Q LC VCOs, the dual-path loop filter, a charge pump, a frequency-phase detector, a multiple modulus prescaler, and a third-order digital $\Sigma\Delta$ modulator. A prototype fabricated with a half-micron CMOS process yielded switching speed within 20 kHz of a new frequency of 100 $\mu$s with −118 dBc/Hz phase noise offset 600 kHz from the carrier frequency. The synthesizer consumes only 30-mW power from a +1.5-VDC supply. See "A 1.5-V 900-MHz Monolithic CMOS Fast-Switching Frequency Synthesizer for Wireless Applications," *IEEE Journal of Solid-State Circuits, International Journal of EMC,* April 2002, Vol. 37, No. 4, p. 459.

## Algorithm Aids In The Calculation Of Complex Frequency Assignments

FREQUENCY ASSIGNMENT TO Txs covering large geographic areas represents a complex problem. Fortunately, Miguel Alabau, Lhassane Idoumghar, and Rene Schott have developed a hybrid genetic algorithm for selecting the most efficient frequency assignments for a particular number of Txs in a particular geographic area. The algorithm uses two original mutation operators and two crossover operators to achieve high-quality solutions with high accuracy. The first mutation operator is based on a greedy algorithm while the second uses a probabilistic tabu search. The mutation operators are based on the idea that by using specialized problem-specific information, the quality of a solution can be enhanced at every iteration, which is converse to the results obtained with other solution approaches. The new algorithm is claimed to improve the best results previously obtained by other methods by 26 percent. See "New Hybrid Genetic Algorithms for the Frequency Assignment Problem," *IEEE Transactions on Broadcasting,* March 2002, Vol. 48, No. 1, p. 27.

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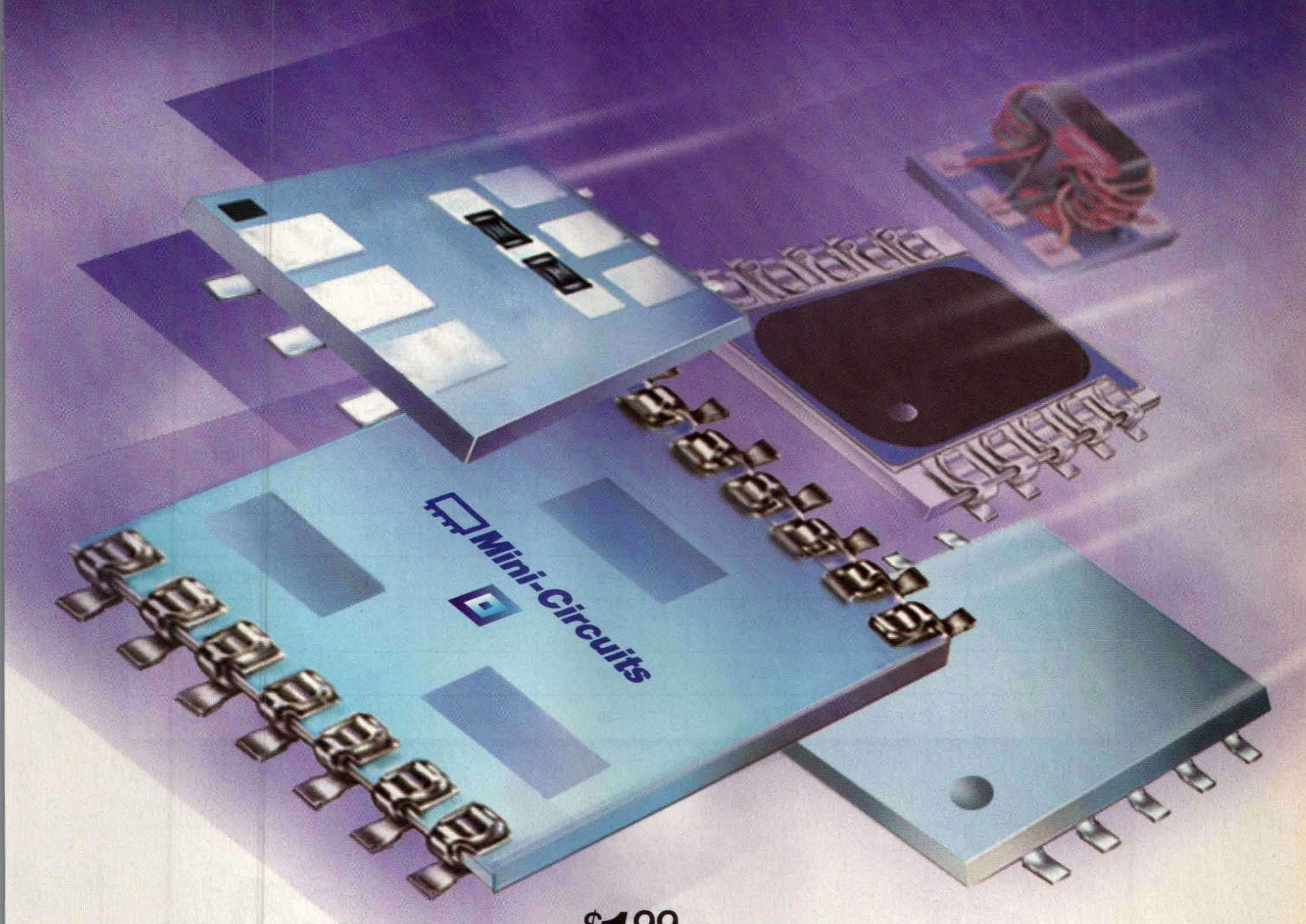


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| 2 | 0 | SBA | 4 | 1200-2600 | 16-22 | 0.4-0.8 | 5.0-10.0 | 6.95 |
| 2 | 0 | SBB | 5 | 800-2300 | 22-24 | 0.5-0.6 | 3.0-4.0 | 4.95 |
| 2 | 90 | QBA | 7 | 340-2400 | 21-28 | 0.25-0.80 | 3.0-7.0 | 6.95 |
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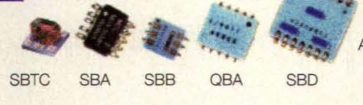


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# EM Approach Sets New Speed Records

**By using an enhanced interpolation method, the speed of multiple-frequency EM analyses increase while maintaining high accuracy.**


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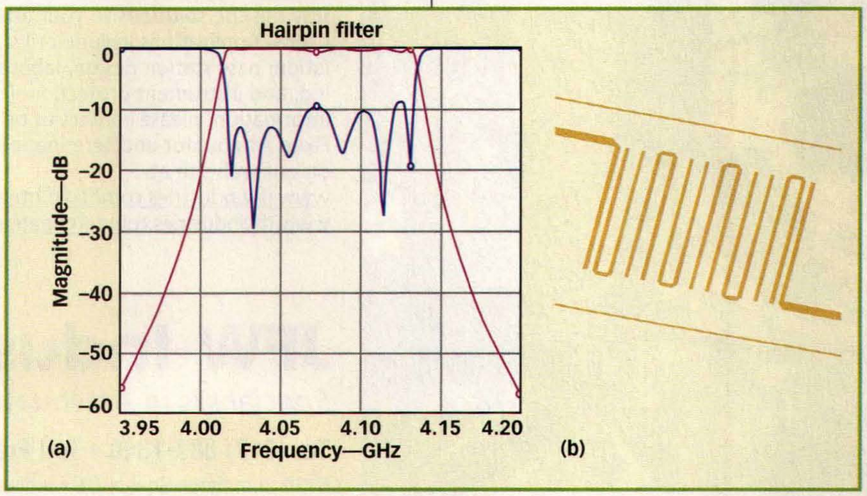
**Achieving ever-faster analysis speeds while maintaining accuracy has been the Holy Grail of electromagnetic (EM) software for some time. Modern EM modeling tools such as the em® software from Sonnet Software (Liverpool, NY) have enjoyed speed benefits due to the increasing performance of computers, but advances in the efficiency of EM software code have been relatively rare until now. With the** release of Version 8.0 of the Sonnet Suite of EM tools, however, a one to two order-of-magnitude increase in speed has been realized for multiple-frequency analyses. The improvement in processing speed enhances a program that is already recognized as the most-accurate software available, and the fastest for a large class of planar circuits.

The gain in speed is achieved by enhancing a well-known interpolation technique.[1,2] By only analyzing a few frequencies, a detailed result over the entire frequency band can be obtained. For example, if four analyses strategically scattered over the passband of a filter are used to synthesize data at 300 frequencies, an increase in speed of 75 times is realized **(Fig. 1)**. This new approach to solving



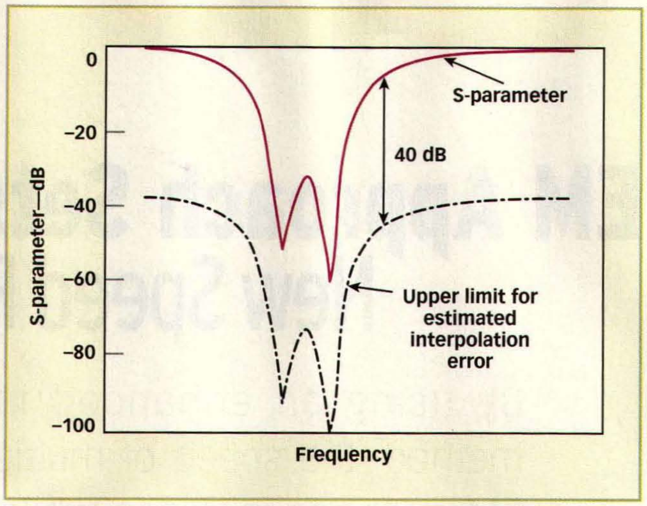

**1. Sonnet ABS interpolation excels with complicated narrowband responses. This hairpin filter required only four analysis frequencies for the calculation of all 300 interpolated data points.**

EM problems is known as Adaptive Band Synthesis (ABS).

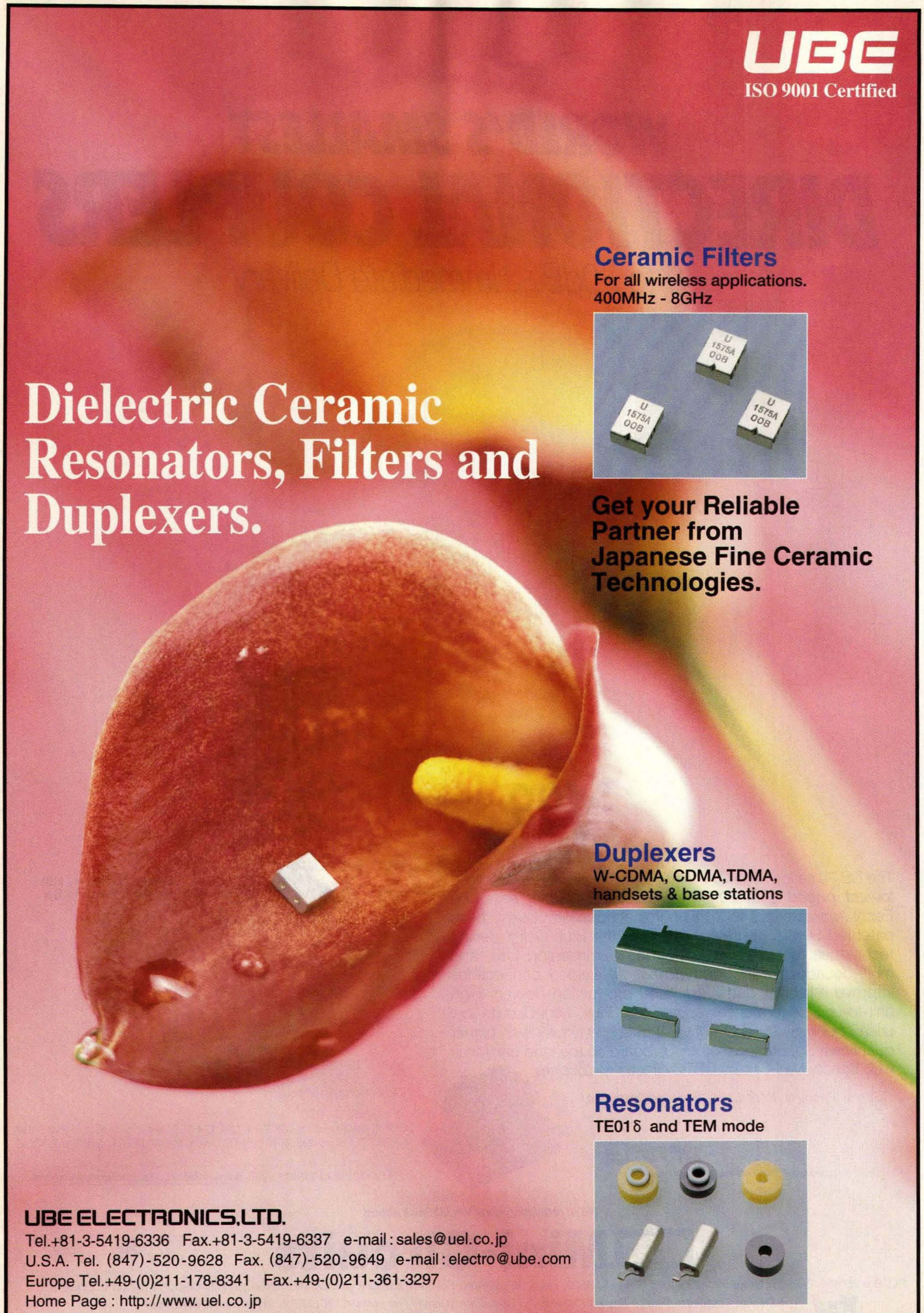
Basic interpolation techniques have been available for some time, but have not been incorporated into Sonnet's computer-aided-engineering (CAE) tools since the usual techniques do not provide the robustness and accuracy needed to meet Sonnet's quality standards. The usual approaches occasionally fail to converge (especially for large-bandwidth analyses) and inaccurate results are sometimes seen, even when convergence is thought to have occurred. But the enhanced interpolation technique that is used in Version 8.0 of the Sonnet Suite is exceptionally robust, efficient, and accurate.

The basic interpolation technique used by Sonnet is the Cauchy method. To understand how the technique works, first consider simple linear interpolation. In linear interpolation, a line drawn between two points is used to find additional points that lie between the two points. In the cubic spline approach, a cubic polynomial is used in the interpolation. The coefficients of the polynomial are set so that its curve passes through four known data points. Additional interpolated points for the cubic spline fall on the curve defined by the polynomial.

Unfortunately, a cubic spline is not quite up to the task of interpolating circuit responses. Except for narrow bands, the scattering (S)-parameters of a circuit, similar to a filter, tend not to fall on a smooth cubic spline-like curve. Rather, recalling Laplace transform theory, circuit responses fall on a curve well-represented by the ratio of two polynomials. This can work for a much wider bandwidth. Specifically, one polynomial is the numerator and a second polynomial is the denominator. The problem then becomes: provided with a set of calcu-




2. Sonnet ABS interpolation continues until the estimated error is more than 40 dB below the interpolated S-parameter at all frequencies, essentially eliminating interpolation error.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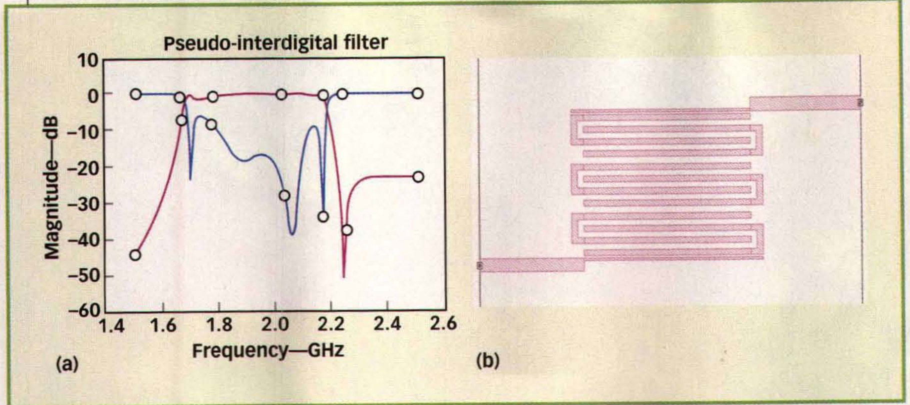



**3. This specially modified hairpin filter requires a few more frequencies due to the octave bandwidth. Transmission and reflection zeros are preferentially selected.**

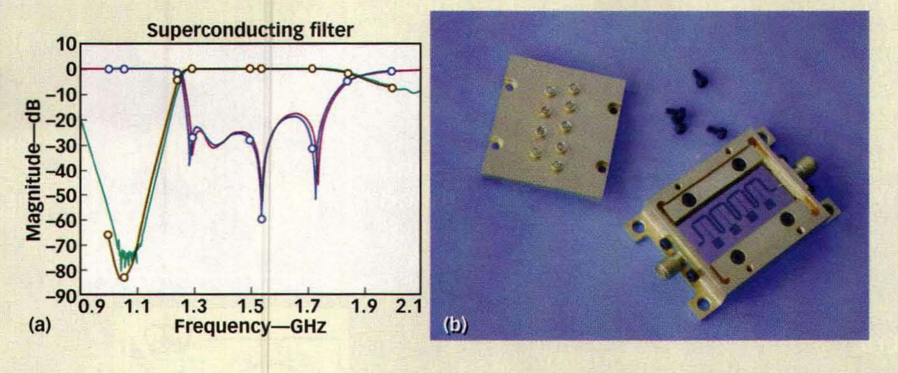
lated data, find the coefficients of the numerator and denominator polynomials so that the ratio of the two passes exactly through each data point. This ratio of polynomials is then used to interpolate the data.

The ratio of the polynomials is known as a Padé rational polynomial. A popular research area in EM studies for most of the last decade, there are several techniques for determining the polynomial coefficients of a Padé rational polynomial, and the Cauchy method is used here. There are some difficulties in using the Cauchy method (and any the other method) that must be addressed to achieve high reliability.

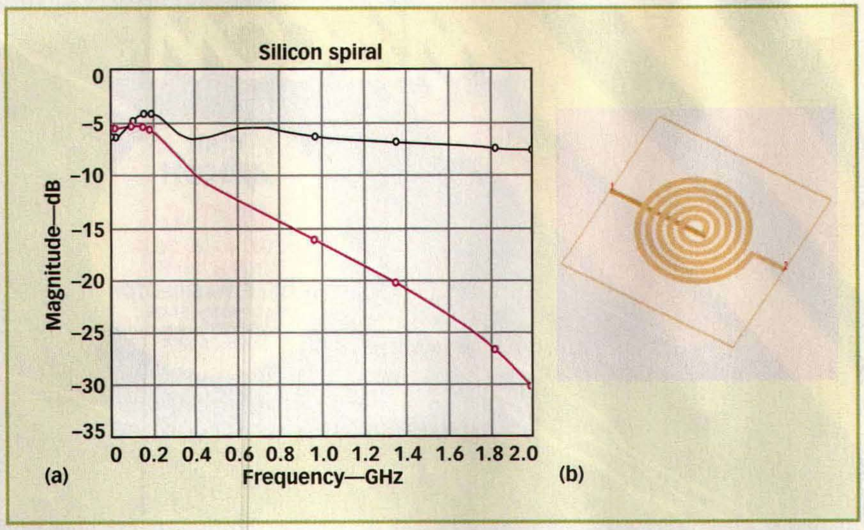
For example, the order of the numerator and denominator polynomials must be properly determined. Additionally, the calculation of the polynomial coefficients requires the inversion of a matrix with elements involving frequency raised to the Nth power. For example, if there are 20 data points, N might be as high as 20. Numbers this large can easily cause numerical-precision problems during matrix inversion.

It is important to have some way to determine the quality of the resulting interpolation. There are several ways to estimate interpolation error. The estimated interpolation error is then used to determine if the analysis has converged and, if not, what frequency is most advantageously analyzed next. Provision must be made for the fact that this estimate of interpolation error may, itself, be off by a considerable amount.

Finally, it should be remembered that distributed circuits are being analyzed, rather than the lumped circuits that have always been analyzed with the Laplace transform. Since certain planar circuits can only be presented over a narrow band by the Padé rational polynomial, there can be a failure to converge in some cases.




**4. A superconducting filter provides the best agreement between measured and calculated data of four different EM tools sampled by the designer.**




**5. For this spiral inductor on Si, ABS interpolation goes to very low frequencies.**

The way Sonnet improves the ability of the Padé polynomial to represent a distributed circuit is by taking advantage of information internal to the method-of-moments (MoM) matrix that is used by the Sonnet EM analysis. This matrix consists of the EM coupling between all subsections in a circuit. Certain select aspects of this matrix are then extracted, allowing a more sophisticated polynomial model to be adaptively synthesized.

This approach supports a large increase in robustness combined with a decrease in the number of frequencies that must otherwise be analyzed. Typically, narrowband results can be obtained with one-half to one-quarter the number of analysis frequencies. Wideband results usually require seven to 15 data points, compared to alternate techniques which often fail to converge at all. The Padé polynomial is still not perfect for representing distributed circuits, but the Sonnet ABS approach does speed the analysis of filters and many other structures.

Part of the information extracted from the MoM matrix is the approximate frequency of transmission and reflection zeros (i.e., frequencies at which the S-parameters go to zero). It has been found that giving priority to analysis at these frequencies results in a significant reduction in the number of required analysis frequencies.

For example, returning to Fig. 1, small circles indicate frequencies that have actually been analyzed. The entire filter response was calculated from analysis at only four frequencies. Both ends of the passband were analyzed first. The interpolation then decides that the best frequency for the next analysis is in the middle of the band. With the information extracted from the moment matrix at only these three frequencies, ABS preferentially places the last analysis exactly on the highest-frequency S11 zero. With these four data points, the estimated interpolation error is now low enough and the algorithm terminates. Full calculation over the entire range yields visually identical results.

The estimation of interpolation error is critical. This is often accomplished by comparing the results of two similar but distinct interpolations, perhaps one with five data points, and a second with six data points. The difference between the two tends to approximate the interpolation error. After running experiments on a large number of circuits, it was found that the actual interpolation error must be at least 20 dB below the magnitude of the S-parameter being interpolated for a plot of the interpolated data to exactly overlay a plot of the actual data visually. In addition, it was found that even the best estimate of error (from comparing two different interpolations) could be off by up to an additional 20 dB. Thus, to be assured of good results, the estimated error must be at least 40 dB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below the magnitude of the S-parameter that is being estimated.

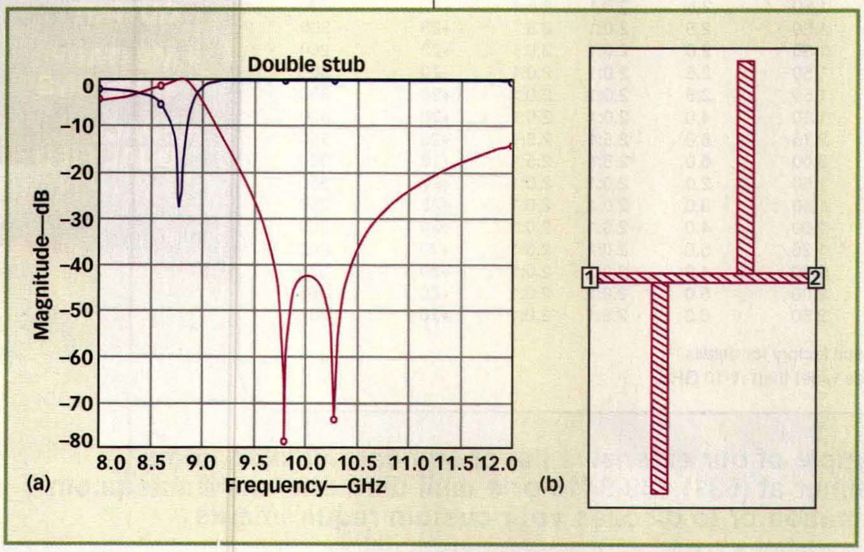
**Figure 2** shows this approach to evaluation of interpolation error. If the interpolated S-parameter is, for example, −60 dB, then the estimated error must be less than −100 dB or the interpolation is not considered converged. When all estimated error is more than 40 dB below the interpolated S-parameters at every frequency, then the interpolation terminates. Since Sonnet uses a Fast Fourier Transform (FFT), and the moment matrix is calculated to full precision, achieving estimated error as low as −140 dB is reasonable. This yields a usable noise floor of approximately −100 dB on interpolated S-parameters.

In contrast, previous techniques might set a uniform limit for estimated interpolation error regardless of how big or small the value of the S-parameter. For example, if a uniform limit of −60 dB is set for the estimated error, the actual error could be up to −40 dB. This means that S-parameters below −20 dB might start to have noticeable interpolation error. Thus, such an interpolation approach has only a −20 dB assured noise floor, often an unacceptable situation. Returning to Fig. 1 once more, note that a −20-dB noise floor could significantly compromise the result. The actual −100-dB noise floor assures a robust result.

The Sonnet ABS interpolation begins with two analyses, one at each end of the band of interest. Then, a preliminary interpolation is attempted and the frequency with maximum estimated interpolation error is determined. If the estimated error is 40 dB or more below the S-parameter magnitude at each frequency, the analysis terminates. Otherwise, the worst interpolated frequency is selected for analysis and the procedure continues. Even after applying this approach to more than 150 trial circuits, no failures have been found. Robustness is a very important goal, and it appears inherent in the ABS technique.

**Figure 3** shows a special kind of hairpin filter similar to that described in refs. 3 and 4, with nonstandard positioning of each resonator. This positioning introduces coupling between nonadjacent resonators, which can cause transmission zeros. Properly positioned, in this case just above the passband, such transmission zeros can significantly increase the filter skirt steepness and reduce in-band group-delay variation. Provided with a second zero below the passband, an "elliptical" filter response would result.

In this case, Sonnet ABS requires




6. The classic double-stub benchmark (b) introduced by Texas Instruments/ Raytheon around 1989 has a double transmission zero due to coupling between identical stubs (a). The two end frequencies and one frequency at each of the three zeros are all that is required to interpolate the entire frequency response.

| Model Number | Frequency Range (GHz) | Gain (Min.) (dB) | Gain Flatness (±dB) | Noise Figure (dB, Max.) | VSWR Input (Max.) | VSWR Output (Max.) | Output Power @ 1 dB Comp. (dBm, Min.) | Nom. DC Power (+15 V, mA) |
|---|---|---|---|---|---|---|---|---|
| **MODERATE BAND AMPLIFIERS** | | | | | | | | |
| AFS2-00700080-05-10P-4 | .7–.8 | 30 | 0.50 | 0.45 | 1.5:1 | 1.5:1 | +10 | 90 |
| AFS2-00800100-05-10P-4 | .8–1 | 30 | 0.50 | 0.45 | 1.5:1 | 1.5:1 | +10 | 90 |
| AFS3-01200160-05-13P-6 | 1.2–1.6 | 40 | 0.50 | 0.45 | 1.5:1 | 1.5:1 | +13 | 150 |
| AFS3-01400170-05-13P-6 | 1.4–1.7 | 40 | 0.50 | 0.45 | 1.5:1 | 1.5:1 | +13 | 150 |
| AFS3-01500180-04-13P-6 | 1.5–1.8 | 40 | 0.50 | 0.40 | 1.5:1 | 1.5:1 | +13 | 150 |
| AFS3-01500250-06-13P-6 | 1.5–2.5 | 36 | 0.50 | 0.60 | 2.0:1 | 2.0:1 | +13 | 150 |
| AFS3-01700190-04-13P-6 | 1.7–1.9 | 36 | 0.50 | 0.40 | 1.5:1 | 1.5:1 | +13 | 150 |
| AFS3-01800220-05-13P-6 | 1.8–2.2 | 36 | 0.50 | 0.50 | 1.5:1 | 1.5:1 | +13 | 150 |
| AFS3-02200230-04-13P-6 | 2.2–2.3 | 36 | 0.50 | 0.40 | 1.5:1 | 1.5:1 | +13 | 150 |
| AFS3-02300270-05-13P-6 | 2.3–2.7 | 34 | 0.50 | 0.45 | 1.5:1 | 1.5:1 | +13 | 150 |
| AFS3-02700290-05-13P-6 | 2.7–2.9 | 32 | 0.50 | 0.50 | 1.5:1 | 1.5:1 | +13 | 150 |
| AFS3-02900310-05-13P-6 | 2.9–3.1 | 32 | 0.50 | 0.45 | 1.5:1 | 1.5:1 | +13 | 150 |
| AFS3-03100350-06-10P-4 | 3.1–3.5 | 29 | 0.50 | 0.6 | 1.5:1 | 1.5:1 | +10 | 150 |
| AFS4-03400420-06-13P-6 | 3.4–4.2 | 40 | 0.50 | 0.60 | 1.5:1 | 1.5:1 | +13 | 225 |
| AFS3-04400510-07-5P-4 | 4.4–5.1 | 30 | 0.50 | 0.70 | 1.5:1 | 1.5:1 | +5 | 100 |
| AFS3-04500480-07-5P-4 | 4.5–4.8 | 30 | 0.50 | 0.70 | 1.5:1 | 1.5:1 | +5 | 100 |
| AFS3-05200600-07-5P-4 | 5.2–6 | 30 | 0.50 | 0.70 | 1.5:1 | 1.5:1 | +5 | 100 |
| AFS3-05400590-07-5P-4 | 5.4–5.9 | 30 | 0.50 | 0.70 | 1.5:1 | 1.5:1 | +5 | 100 |
| AFS3-05800670-07-5P-4 | 5.8–6.7 | 30 | 0.50 | 0.70 | 1.5:1 | 1.5:1 | +5 | 100 |
| AFS3-07250775-06-5P-4 | 7.25–7.75 | 30 | 0.50 | 0.60 | 1.5:1 | 1.5:1 | +5 | 100 |
| AFS3-07900840-07-5P-4 | 7.9–8.4 | 30 | 0.50 | 0.70 | 1.5:1 | 1.5:1 | +5 | 100 |
| AFS4-08500960-08-5P-4 | 8.5–9.6 | 32 | 0.75 | 0.80 | 1.5:1 | 1.5:1 | +5 | 125 |
| AFS3-09001100-09-5P-4 | 9–11 | 26 | 0.50 | 0.90 | 1.5:1 | 1.5:1 | +5 | 100 |
| AFS4-09001100-09-5P-4 | 9–11 | 32 | 0.75 | 0.90 | 1.5:1 | 1.5:1 | +5 | 125 |
| AFS4-10951175-09-5P-4 | 10.95–11.75 | 32 | 0.75 | 0.90 | 1.5:1 | 1.5:1 | +5 | 125 |
| AFS4-11701220-09-5P-4 | 11.7–12.2 | 32 | 0.75 | 0.90 | 1.5:1 | 1.5:1 | +5 | 125 |
| AFS2-12201280-10-8P-4 | 12.2–12.8 | 14 | 0.75 | 1.00 | 1.5:1 | 1.5:1 | +8 | 80 |
| AFS4-12201280-10-12P-4 | 12.2–12.8 | 27 | 0.75 | 1.00 | 1.5:1 | 1.5:1 | +12 | 200 |
| AFS4-12701330-13-10P-4 | 12.7–13.3 | 27 | 0.75 | 1.30 | 1.5:1 | 1.5:1 | +10 | 175 |
| AFS4-13201400-14-10P-4 | 13.2–14 | 24 | 0.75 | 1.40 | 1.5:1 | 1.5:1 | +10 | 175 |
| AFS4-14001450-14-10P-4 | 14–14.5 | 24 | 0.75 | 1.40 | 1.5:1 | 1.5:1 | +10 | 175 |
| AFS4-20202120-20-8P-4 | 20.2–21.2 | 20 | 1.00 | 2.00 | 1.5:1 | 1.5:1 | +8 | 175 |
| AFS4-21202400-22-10P-4 | 21.2–24 | 18 | 1.00 | 2.2 | 2.0:1 | 2.0:1 | +10 | 100 |
| **OCTAVE BAND AMPLIFIERS** | | | | | | | | |
| AFS3-00120025-09-10P-4 | .12–.25 | 38 | 0.50 | 0.9 | 2.0:1 | 2.0:1 | +10 | 175 |
| AFS3-00250050-08-10P-4 | .25–.5 | 38 | 0.50 | 0.8 | 2.0:1 | 2.0:1 | +10 | 125 |
| AFS3-00500100-05-10P-6 | .5–1 | 38 | 0.75 | 0.5 | 2.0:1 | 2.0:1 | +10 | 150 |
| AFS3-01000200-05-10P-6 | 1–2 | 38 | 1.00 | 0.5 | 2.0:1 | 2.0:1 | +10 | 150 |
| AFS3-01200240-05-10P-6 | 1.2–2.4 | 34 | 1.00 | 0.5 | 2.0:1 | 2.0:1 | +10 | 175 |
| AFS3-02000400-06-10P-4 | 2–4 | 30 | 1.00 | 0.6 | 2.0:1 | 2.0:1 | +10 | 125 |
| AFS3-02600520-10-10P-4 | 2.6–5.2 | 28 | 1.00 | 1.0 | 2.0:1 | 2.0:1 | +10 | 150 |
| AFS3-04000800-07-10P-4 | 4–8 | 30 | 1.00 | 0.7 | 2.0:1 | 2.0:1 | +10 | 125 |
| AFS3-08001200-09-10P-4 | 8–12 | 26 | 1.00 | 0.9 | 2.0:1 | 2.0:1 | +10 | 125 |
| AFS3-08001600-15-8P-4 | 8–16 | 26 | 1.00 | 1.5 | 2.0:1 | 2.0:1 | +8 | 80 |
| AFS4-12002400-25-10P-4 | 12–24 | 20 | 2.00 | 2.5 | 2.0:1 | 2.0:1 | +10 | 85 |
| AFS4-12001800-18-10P-4 | 12–18 | 26 | 1.00 | 1.8 | 2.0:1 | 2.0:1 | +10 | 125 |
| AFS4-18002650-28-8P-4 | 18–26.5 | 18 | 1.75 | 2.8 | 2.5:1 | 2.2:1 | +8 | 150 |
| **MULTIOCTAVE BAND AMPLIFIERS** | | | | | | | | |
| AFS1-00040200-12-10P-4 | .04–2 | 15 | 1.50 | 1.2 | 2.5:1 | 2.0:1 | +10 | 75 |
| AFS3-00300140-08-10P-4 | .3–1.4 | 33 | 1.00 | 0.8 | 2.0:1 | 2.0:1 | +10 | 150 |
| AFS2-00400350-12-10P-4 | .4–3.5 | 22 | 1.50 | 1.2 | 2.0:1 | 2.0:1 | +10 | 80 |
| AFS3-00500200-08-15P-4 | .5–2 | 38 | 1.00 | 0.8 | 2.0:1 | 2.0:1 | +15 | 125 |
| AFS3-01000400-09-10P-4 | 1–4 | 30 | 1.50 | 0.9 | 2.0:1 | 2.0:1 | +10 | 125 |
| AFS3-02000800-09-10P-4 | 2–8 | 26 | 1.00 | 0.9 | 2.0:1 | 2.0:1 | +10 | 125 |
| AFS4-02001800-23-10P-4 | 2–18 | 25 | 2.00 | 2.3 | 2.0:1 | 2.0:1 | +10 | 175 |
| AFS4-06001800-22-10P-4 | 6–18 | 24 | 2.00 | 2.2 | 2.0:1 | 2.0:1 | +10 | 150 |
| AFS4-08001800-22-10P-4 | 8–18 | 26 | 2.00 | 2.2 | 2.0:1 | 2.0:1 | +10 | 150 |
| **ULTRA WIDEBAND AMPLIFIERS** | | | | | | | | |
| AFS3-00100100-09-10P-4 | .1–1 | 38 | 1.00 | 0.9 | 2.0:1 | 2.0:1 | +10 | 150 |
| AFS3-00100200-10-15P-4 | .1–2 | 38 | 1.00 | 1.0 | 2.0:1 | 2.0:1 | +15 | 150 |
| AFS3-00100300-11-10P-4 | .1–3 | 32 | 1.00 | 1.1 | 2.0:1 | 2.0:1 | +10 | 150 |
| AFS3-00100400-13-10P-4 | .1–4 | 28 | 1.00 | 1.3 | 2.0:1 | 2.0:1 | +10 | 150 |
| AFS3-00100600-13-10P-4 | .1–6 | 28 | 1.25 | 1.3 | 2.0:1 | 2.0:1 | +10 | 125 |
| AFS3-00100800-14-10P-4 | .1–8 | 25 | 1.50 | 1.4 | 2.0:1 | 2.0:1 | +10 | 125 |
| AFS4-00101200-22-10P-4 | .1–12 | 28 | 1.50 | 2.2 | 2.0:1 | 2.0:1 | +10 | 175 |
| AFS4-00101400-23-10P-4 | .1–14 | 24 | 2.00 | 2.3 | 2.5:1 | 2.5:1 | +10 | 200 |
| AFS4-00101800-25-10P-4 | .1–18 | 25 | 2.00 | 2.5 | 2.5:1 | 2.5:1 | +10 | 175 |
| AFS4-00102000-30-10P-4 | .1–20 | 20 | 2.50 | 3.0 | 2.5:1 | 2.5:1 | +10 | 175 |
| AFS4-00102650-40-8P-4 | .1–26.5 | 18 | 2.50 | 4.0 | 2.5:1 | 2.5:1 | +8 | 175 |

Note: Noise figure increases below 500 MHz in bands greater than 0.1-10 GHz.

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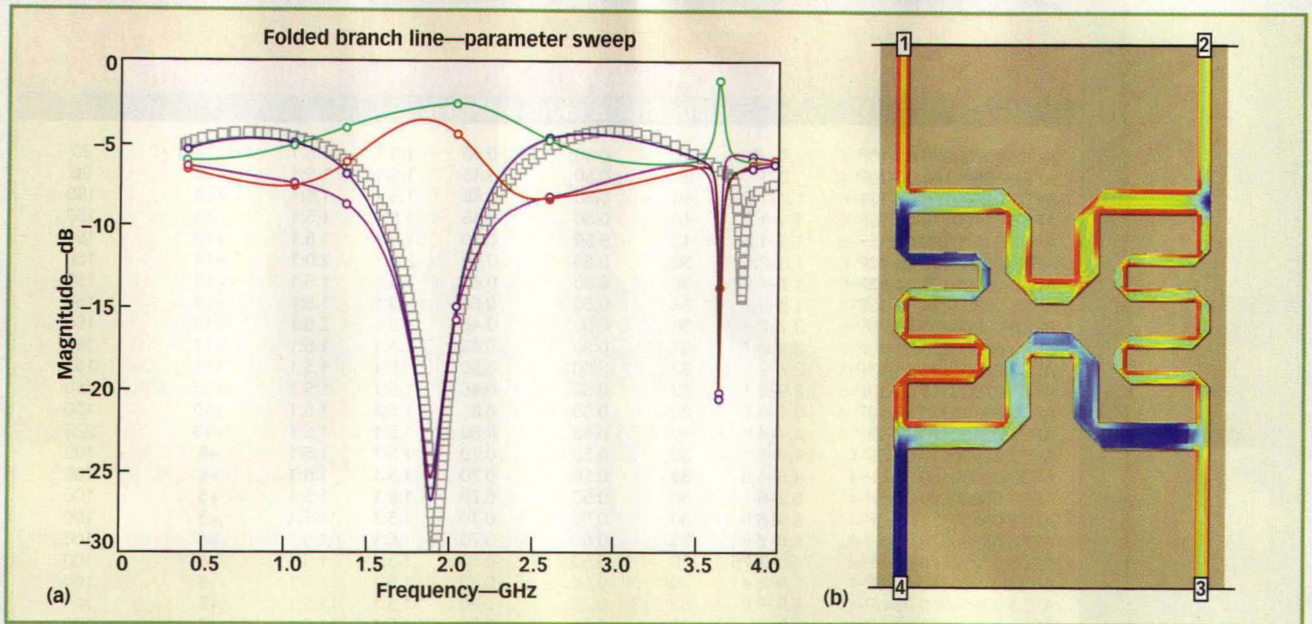
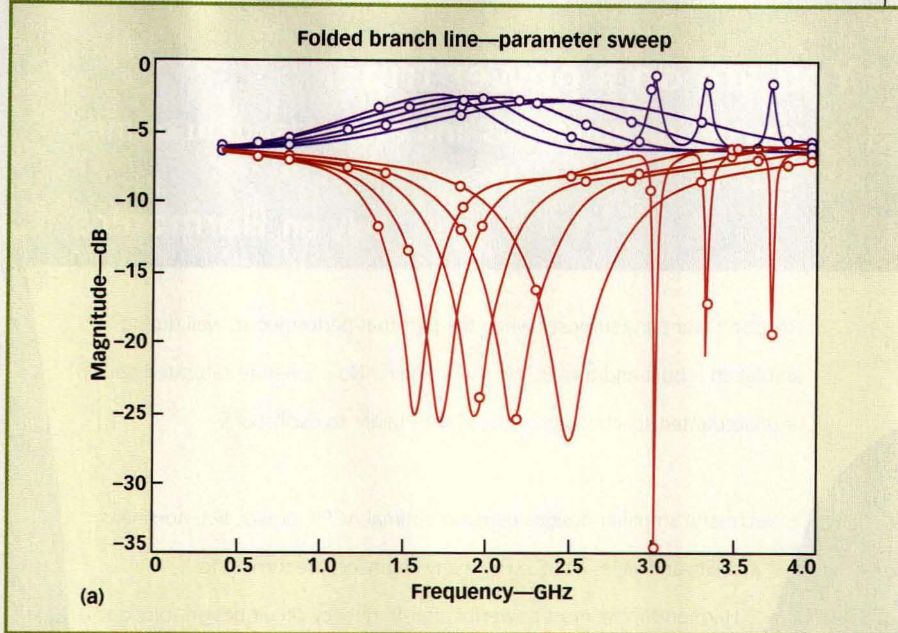
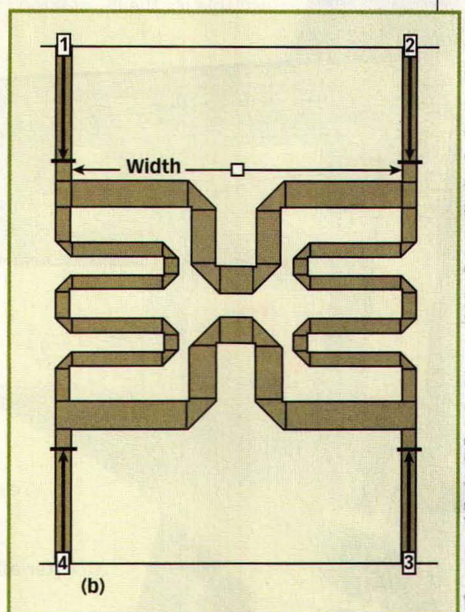



seven analysis frequencies. In addition to the first and last frequencies, five frequencies are scattered through the passband, each getting closer to filter zeros as the interpolation successively extracts better information about the zeros. The reason more data is needed, as compared with the previous filter, is that this analysis covers a one-octave (factor of two) bandwidth. The analysis in Fig. 1 covers slightly less than a 10-percent bandwidth. As is true for ABS and all the other

**7. The folded branch-line coupler requires only eight frequency points to cover a decade bandwidth. The first four S-parameters are shown along with the worst-case measured data (for S11).**




**8. The width (distance between two input ports) has been parameterized and swept over five values (a), with the widest case shown in (b). Each case required only seven or eight analysis.**

techniques, larger bandwidths require more data points.

**Figure 4** shows a superconducting filter designed to remove clutter in a radio astronomy application. Nine data points were required for the analysis of the filter's passband. Constraints in budget and time limited the designers to only one fabrication, so first-pass success was a critical design requirement. This filter was analyzed using four different EM CAD tools. Sonnet, with an analysis time of 5 min. per frequency was the fastest and also provided data closest to the measured results (also plotted in Fig. 4).

For this filter, Sonnet's 5-min. analysis time was achieved by a relatively new user. In the hands of an expert Sonnet user, analysis time was reduced to 30 s/frequency (having a faster computer also helped). As an indication of the cell size used, the narrow vertical lines are subsectioned six cells across.

**Figure 5** shows a spiral inductor on a silicon (Si) substrate. Sonnet typically shows exceptional accuracy when analyzing this kind of inductor. Due to use of the FFT (which provides the accuracy), circular spirals such as the one in Fig. 5 take several minutes per frequency for analysis. In comparison, equivalent square spirals can be analyzed in only seconds. In this case, analysis at nine frequencies provides enough information for the 300 data points plotted. The approach sometimes tends to cluster data points at low frequencies. If the bottom 10 percent of the frequency range is not needed, however, the number of data points could be cut in half.

**Figure 6** shows a classic microstrip double stub. This circuit was one of the first benchmarks used to validate Son-

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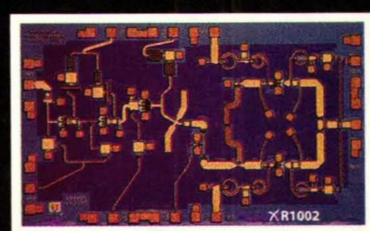


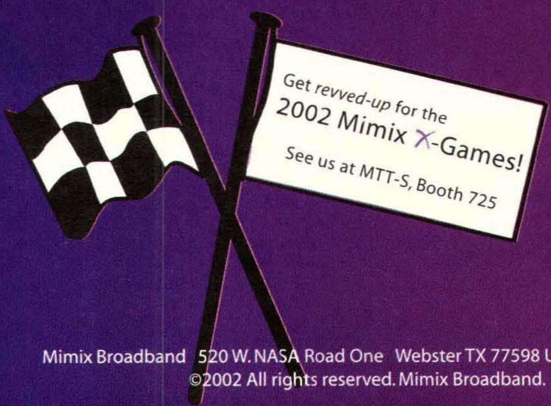


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net in 1989. Generated by Texas Instruments/Raytheon, the two identical stubs couple enough to produce two deep transmission zeros. With the very small cell size used in Fig. 6 (the stubs are subsectioned eight cells across) this problem was too large for 1989 technology and hardware (the validation was completed by switching to a larger cell size). Today, this analysis requires 1 s/frequency.

**Figure 7** shows the first four S-parameters of a folded branch-line coupler. The measured data, which shows the worst agreement with calculated data (S11), is also plotted. The ABS approach required analysis at only eight frequencies, generating 300 data points and covering an entire decade of bandwidth. The narrowest lines are 20 cells wide.

Sonnet can also automatically sweep parameters and optimize. **Figure 8** shows the result of sweeping the width (distance between the two input ports) of the folded branch-line over five values. The widest case is shown in Fig. 8(b). With Sonnet ABS, only seven or eight data points are needed for each case. A total of 38 frequencies were analyzed, providing 300 frequency data points for each of five coupler widths.

The ABS technology is available this summer in the company's Sonnet Suite of EM tools, as well as in the free SonnetLite package (available at www.sonnetusa.com starting June 3). Sonnet and ABS are both trademarks of Sonnet Software, Inc. MRF


ACKNOWLEDGMENTS

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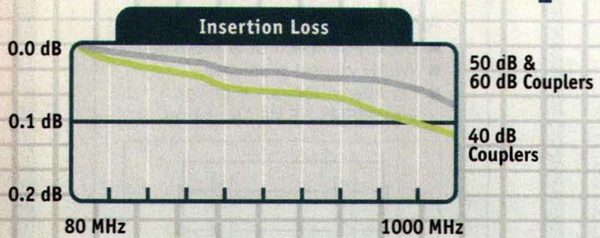


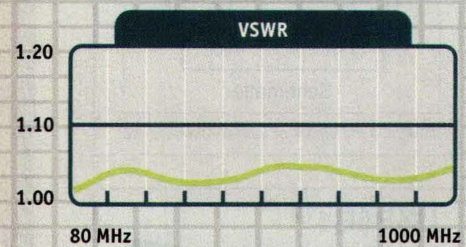


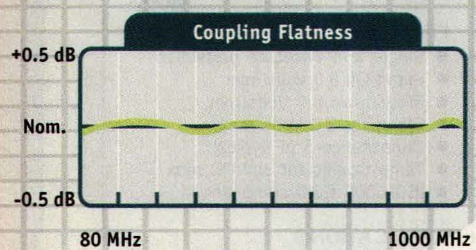


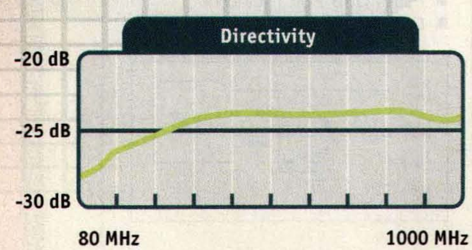


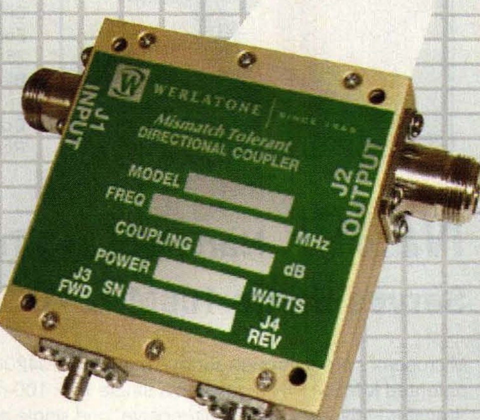


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# Base-Station Antennas Offer Dual Polarization

These base-station antennas incorporate unique elements and integrated beam-forming networks to achieve omnidirectional dual-polarization patterns in a low-profile design.

**DR. JAMAL S. IZADIAN**
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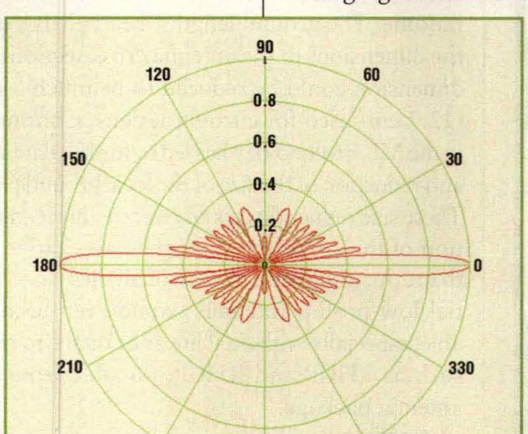
**Low-profile, base-station antennas are desirable not only for installation of unobtrusive cell sites, but also for their tendency to minimize wind loading. An innovative approach has been developed for these antennas using patented meander-line-antenna (MLA) elements to form low-profile, lightweight, dual-polarized linear arrays with smooth omnidirectional patterns. In addition, the arrays are modular,** allowing the stacking of two similar subarrays to form a larger array with higher gain. Each subarray can achieve 12.5-dBi gain in both polarizations, with 15-dBi gain possible from two stacked subarrays, with excellent omnidirectional azimuth and elevation patterns. In support of the dual polarization, innovative dual-track beam-forming networks (BFNs) were integrated into the arrays.

High-gain antennas with improved electrical performance, enhanced aesthetic quality, and environmental compatibility are essential to the increased growth of cellular communications systems. These antennas should offer multifunctional capabilities and also be lightweight. Furthermore, the antennas should meet the needs of municipal, state, and federal authorities on location and appearance, as well as Federal Communications Commission (FCC) regulations and other standards on the efficient use of frequencies and the control of unwanted emissions.

To meet the needs of this multitude of requirements, low-profile modular antennas have been developed with high omnidirectional gain and dual-polarization capability. The antennas are formed from a combination of two modular antennas or subarrays, which can be operated individually or stacked and combined into a larger antenna with nearly 3-dB additional gain compared to each subarray. The antenna design can be reconfigured in the field manually (through switching) or automatically (under computer control) to provide horizontal and vertical polarizations simultaneously or right-hand




**1. Theoretical azimuth pattern of a 12-element linear array of isotropic elements is shown here.**

**2. A single MLA element is shown on an 18 × 18-in. (45.72 × 45.72-cm) ground plane.**

circular polarization (RHCP) and left-hand circular polarization (LHCP) simultaneously. This flexibility makes this antenna-design approach attractive for "smart" antenna arrays and base stations, as well as for third-generation (3G) mobile communications systems.

The high gain of these base-station antenna arrays are made possible by innovative, low-loss, dual-track BFNs integrated with the antenna structure. This integration helps to minimize signal-path losses and phase variations, yielding high-efficiency antenna arrays.

Although this design and construction approach employs uniform phase and amplitude distributions, the same technology can be used to accommodate amplitude tapering for sidelobe control. It can also accommodate any required phase distribution to provide pattern tilt in the elevation for uniform cell coverage and compensated cosecant distribution. The technology supports low-cost power distribution as well as phase matching for low ripple.

In addition to efficient BFNs for high gain, this approach also requires high-gain antenna elements, especially for omnidirectional patterns. The MLA element is one of the best candidates for this design approach. Patented MLA technology, originally developed for defense applications, uniquely provides high gain due to its apparent large electrical length in a physically small form factor, characteristics exhibited by few other approaches. With the new design approach, efficient MLA elements offer an effective method of developing low-profile, lightweight omnidirectional antennas with great uniformity in azimuth and excellent polarization selectivity and isolation.

Subarrays developed based on this approach were approximately 50 × 5 in. (127 × 12.7 cm), including a cylindrical radome. The ground length of each MLA element dictated the dimensions of the antenna cross-section. Altogether, this dimension could be reduced to be much less than the 5 in. (12.7 cm) used for current designs. Continued innovations in the MLA technology has led to further flattening of the height and reduction of the size of the local ground plane of the MLA. These size reductions could conceivably lead to further reduction of the cross section of the base-station antenna to less than 2 in. (5.08 cm). In view of all these innovations, a potential low-profile antennas would even become more desirable, especially with dual linear or dual circular polarizations, such as LHCP and RHCP, possible from the same small antenna package.

**Figure 1** shows a typical theoretical radiation pattern of a linear array of isotropic sources. The pattern is the result of 12 elements with uniform spacing, and uniform amplitude

3. Two dual-polarized antennas subarrays are shown side by side (a) and joined in the middle (b) to form a larger array with approximately 3-dB more gain than a single MLA element.

(a) (b)



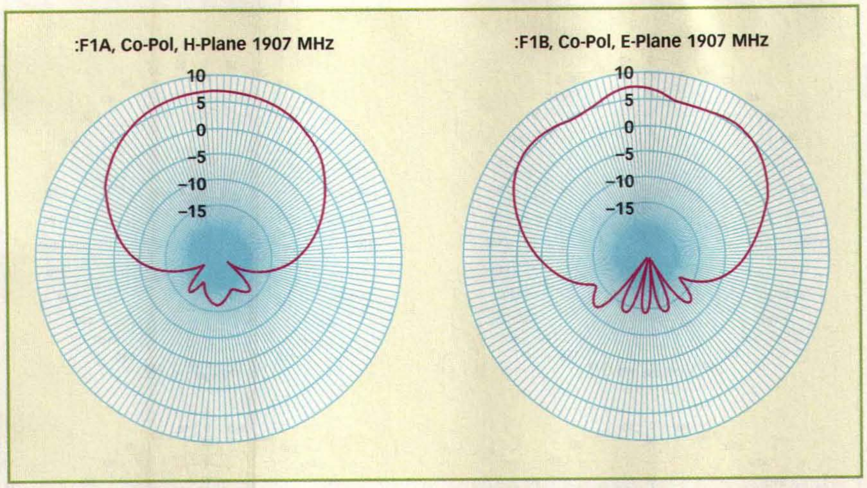
and phase distributions. The theoretical directivity of this antenna is approximately 12 dBi. This was the basis for the array design. This is the expected elevation pattern, with an omnidirectional pattern expected for the azimuth. The measured pattern for the antennas will only show one-half of the pattern, due to test-range angular-movement limitations.

A traditional omnidirectional, vertically polarized antenna array is achieved by stacking wire dipoles and using intermediate current-phasing coils. Achieving a low-profile, vertical-polarization design with this approach is difficult, however, requiring some type of loop or horizontal resonant slots. Attaining multiple polarizations complicates the design even further.

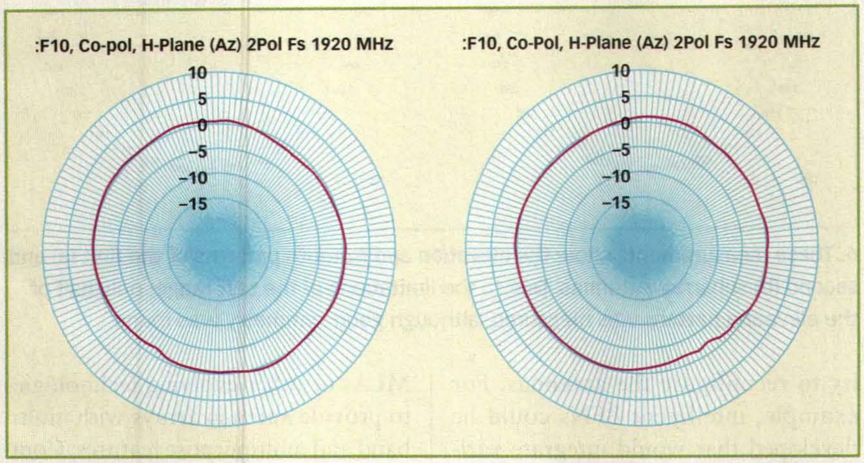
The MLA elements are attractive candidates for low-profile antenna designs because they are small in size, yet provide high gain and can be combined in sectors to provide good omnidirectional coverage **(Fig. 2)**. Based on this building-block component, two linear subarrays, each with approximately 100 MLA elements, were designed and constructed. The BFNs were developed as an integral part of the antennas. They were developed with a uniform power and phase distribution. A total of approximately 200 MLA elements were used for the full antenna.

**Figure 3a** shows two subarrays side by side (shown tied together for shipping), while **Fig. 3b** shows two subarrays connected in the center to form a larger antenna with approximately 3-dB more gain than a single subarray. The low profile of the antenna shows very little obstruction and has very low wind loading, thus making it a suitable choice of technology for future generations of base-station antennas.

**Figure 4** shows the radiation pat-




4. These plots show the H-plane (left) and E-plane (right) radiation patterns for a single MLA at 1.907 GHz.

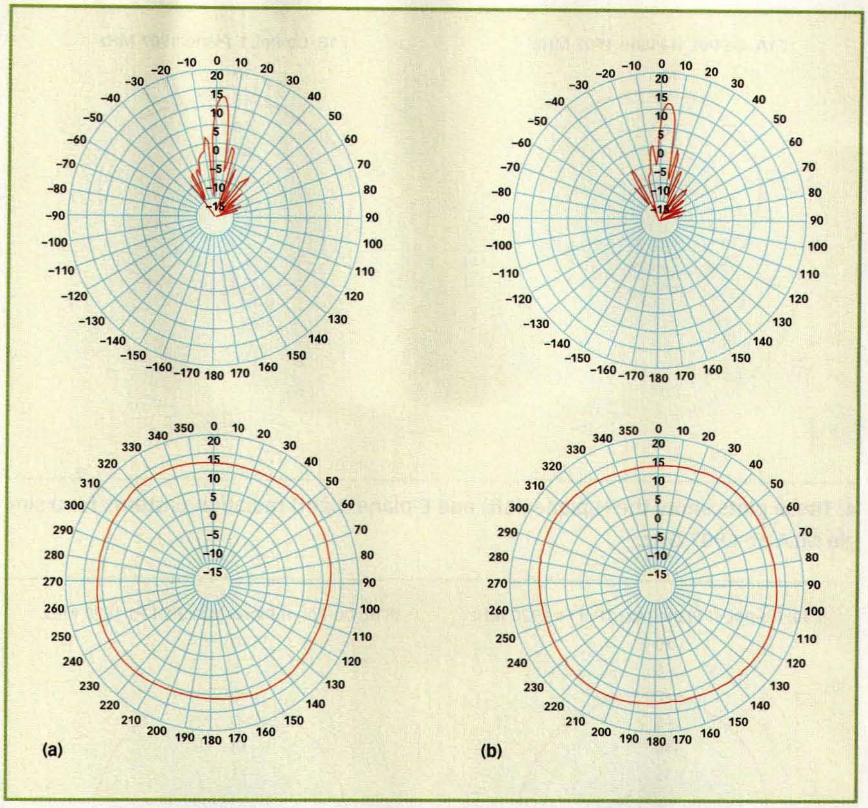



5. These plots show the measured H-plane (left) and E-plane (right) patterns for a combination of four vertical MLA elements positioned around a metallic pipe, collocated with another set of elements in the horizontal direction at 1.92 GHz.

terns for a single MLA at 1.907 GHz, while **Fig. 5** shows the measured H-plane (left) and E-plane (right) patterns for a combination of four MLA elements positioned around a metallic pipe, collocated with another set of elements in the horizontal direction. The horizontal and vertical omnidirectional patterns are similar, with a slight amount of ripple. More careful phase matching would reduce the ripple to a desired limit of approximately 0.5 dB, to implement a high-gain, low-ripple omnidirectional antenna.

**Figure 6a** shows the elevation and azimuth-radiation patterns of one of the antennas in Fig. 3, in the horizontal polarization, while **Fig. 6b** shows the radiation pattern of second subarray in Fig. 3. The vertical-polarization pattern is very similar and thus not included. Finally, **Fig. 7** shows the radiation pattern of the larger antennas constructed by stacking two subarray antennas in Fig. 3. The radiation patterns show approximately 15-dBi gain, with uniform omnidirectional pattern for the horizontal polarization. The pattern for the vertical polarization is similarly uniform. The antenna is approximately 100 × 5 in. (254 × 12.7 cm). This is truly an innovative design, considering its low profile and its well-behaved simultaneous horizontal and vertical polarizations or simultaneous RHCP and LHCP.

Another feature that can be achieved in this design is the flexibility and abil-




**6. These measurements show the elevation and azimuth patterns of the first (a) and second (b) subarray antennas. Due to the limitations of the test range, only half of the elevation pattern was measured, although good symmetry was found.**

ity to reconfigure the antennas. For example, intelligent BFNs could be developed that would integrate various additional functions, such as electronic switches, phasing elements, and hybrid couplers to provide any combination of the following:

- Adding two subarrays to form a larger array.
- Switching polarization from linear to circular polarization.
- Changing the polarization sense of the circular polarization.
- Steering beam and having beam-tilt adjustments to accommodate traffic.
- Adaptive interference null steering.
- Beam shaping and sidelobe reconfiguration on the fly.
- Sequential-sector switching, from 90 to 360 deg. (omnidirectional).
- Band selection/switching and or simultaneous multiband operation.

Additionally, the integrated BFN exhibited extremely smooth broadband behavior. This readily enables the use of multiband antenna elements such as MLAs or other evolving technologies to provide antenna arrays with multiband and multipurpose features. Combined with aluminum (Al) frames, the MLA technology could provide low-weight, low-profile base-station antennas with reduced wind loading, requiring smaller and lower-cost towers.

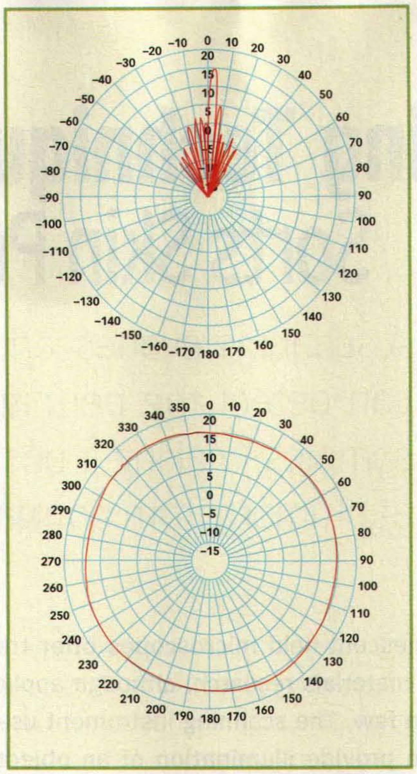
Although this antenna was designed for eventual insertion into a thin cylindrical radome, the design revealed very little sensitivity to material proximity (mainly due to balanced currents and thus an absence of otherwise spurious surface currents) and may eventually be immersed into a liquid plastic-like material for complete hermetic sealing, completely eliminating the need for an external radome. This idea becomes very attractive when the lower-profile flat MLAs or other similar antenna-element technologies are used.

These antenna arrays can employ any other suitable high-gain miniature-antenna elements. The MLAs will find little competition, however, when it

comes to delivering high gain (a characteristic of much larger antennas) for their small size. Furthermore, the MLAs provide very clean and well-defined polarization characteristics, easing the way for the development of dual-polarization antennas with low cross-polarization on the order of better than 30 dB.

Each subarray antenna exhibits approximately 12.5-dBi gain. When the two antenna subarrays were stacked and combined, they formed a single longer antenna with approximately 15-dBi omnidirectional gain for both polarizations. The test-range-measurement uncertainty for this measurement is approximately ±0.5 dB. In the transition from a single array to the final longer antenna, the measured frequency exhibited a shift, but no attempts were made at tuning. Test results at 1.92 GHz are shown for those conditions under which the best input return loss was obtained. Because the BFNs were designed with isolation resistors, superior output and input matching was possible over a large bandwidth. The BFNs themselves provide superior low-loss signal paths, helping to form a highly efficient antenna array. Extreme care was taken to phase match the signal paths to assure maximum gain and to avoid signal tilting. The same care can be used to phase match the signal paths in the BFN to provide a moderate beam tilting with very small incremental effort in manufacturing.

Although these antennas were designed for moderate power levels to 20 W, they could easily be extended to powers up to 100 W without significant modifications. Because the subarray antenna structures were constructed mostly in one piece, it is believed that they will have very low intermodulation-product (IMP) problems. Further innovations can lead to even more single-piece manufacturing which could provide method for IMP-free operation at moderately higher power levels. Eventually, the antennas could be designed into a single superstructure, thus lowering the number of metal-to-metal joints, and thus reducing the possibilities of the nonlinear effects, and therefore reducing the magnitude of passive IMPs.



7. These elevation- and azimuth-pattern measurements were made for the two stacked and combined MLA subarrays, with only half of the elevation pattern measured due to the limits of the test range.

The novel design did not include any higher-order effects, such as mutual coupling and proximity effects. The shift in frequency could be due to several factors, such as mutual coupling or higher-order effects, as well as the ground effect of the antenna structure. The measured gains were slightly higher than predicated according to theory. This discrepancy could be partially due to the fact that the antenna's frequency shifted upward, making the antenna appear electrically larger. In all cases, fabricated antennas performed well, indicating that the design process lends itself to low-cost mass production, while keeping structural tolerances to a minimum. MRF

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# Scanning Technique Sorts Skin Permittivity

A scanning evanescent-field microscope can detect the permittivity of biological samples, making it possible to differentiate tumors from normal skin.

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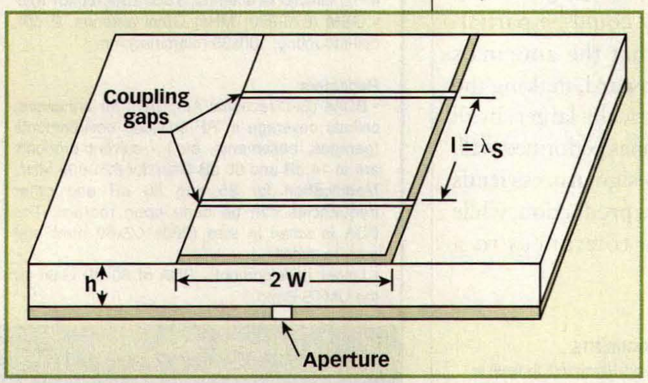
**Scanning evanescent-field microscopes offer tremendous potential for materials research, although applications so far have been few. The scanning instrument uses evanescent fields to provide illumination of an object within a small aperture. The aperture can be scanned over an object of interest, providing results with resolution that is less than the aperture diameter. Of the unrealized potential for** this instrument, one application includes the scanning of biological samples, such as human skin with tumors to detect tumors from healthy tissue.

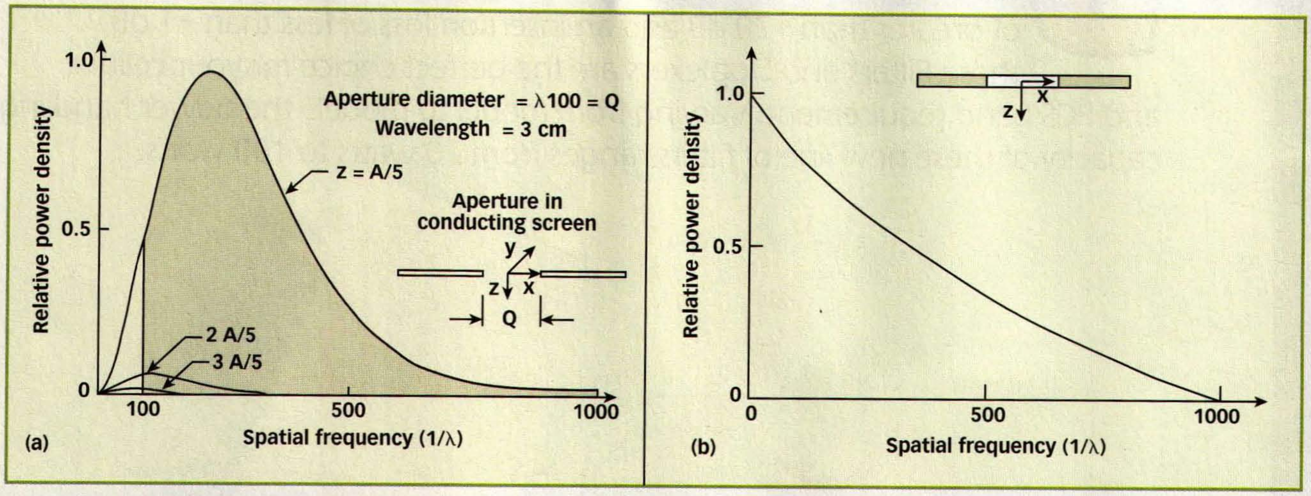
While many authors[1-12] have reported the development of the microscope, the scanning evanescent-field microscope is only in its early stages. The device has been developed with the use of spatial-frequency spectrum of aperture fields. It leads to the prediction of signal strength as a function of the object from the aperture screen. An expression is derived to determine the dielectric property of a material, while a theory of dipole approximation to the aperture field provides a change in the electric and magnetic properties of a specimen.




**1. A microstrip resonator with an aperture in the ground plane is seen here.**

An evanescent-field generator can be constructed by connecting an evanescent waveguide to a waveguide resonator. The approach has been used[3] to detect cracks in a steel sample. In ref. 3, a microstrip resonator has been described with an aperture in the ground plane. An analysis on the signal arising from a frequency shift to the input power is derived from stored energy in the microstrip resonator and the evanescent field outside the aperture.

Evanescent microwave principles of operation are based on the work of refs. 3, 7, 8, and 9. When a dielectric/semiconductor/biological material is placed in the vicinity of the evanescent field, the reflection coefficient of the resonator changes. The resonance frequency and quality factor (Q) of the cavity resonator are affected by the dielectric characteristics of the material. The amount of change in the resonance depends on the microwave properties of the sample and the effective area of sample in the evanescent field. The microwave properties of a material are shown to be a function of permittivity and permeability. These parameters and density variations, which affect the permittivity, can be presented using an




**2. Relative power density (x-direction) versus spatial frequency ($1/\lambda_o$) is seen here, while relative power density in the z-direction versus spatial frequency ($1/\lambda_o$) is also shown.**

evanescent-field technique.

**Figure 1** shows a microstrip resonator with an aperture in the ground plane. The criteria is to maximize interactions between the aperture field and an object of interest. In this case, the signal is proportional to the energy stored in the fields outside the aperture, $W_o$, and inversely proportional to the energy stored in the resonator, $W_r$. The ratio $W_o/W_r$ must be increased to increase the resolution. However, the increase in $W_o$ may be affected by confining the fields, illuminating the aperture into the smallest possible area so that maximum field intensity occurs at the aperture.

The imaging property of the instrument is determined by the evanescent fields produced by the cavity aperture. A high evanescent field contains spatial frequencies which are much higher than the inverse wavelength. Using the electric-dipole approximation to the aperture theory, the transverse spectral-density function in the x-direction was computed. The plot is shown in **Fig. 2a**. The calculation is performed for the aperture diameter (x) = λ/100 and the typical operating distance away from the diaphragm (z) = λ/1000.

Spectrum power density in the z-direction has been computed from Beth's approximation,[13] which has been plotted in **Fig. 2b**.

The instrument consists of an aperture that is in one of the side walls of a resonant cavity which, in this case, is a microstrip resonator as shown in Fig. 1. The sample beneath the hole perturbs the resonator frequency. By operating on the linear portion of the resonator's Q curve, this frequency shift can be translated into a corresponding amplitude change. The sample is illuminated by the evanescent field that is associated with the small aperture. Therefore, a signal needs to be detected which is very small compared to the illumination power. This is needed to obtain a significant improvement over the classical resolution. Moreover, this signal is superimposed on much larger background radiation so that the contrast will be poor. This deficiency can be overcome by vibrating the sample at a low frequency. The required signal is then tagged by this modulation frequency and is readily separated in the receiver (Rx) system.

Figure 1 shows a microstrip resonator based on Wheeler's[14] formulas. It consists of two discontinuities in the microstrip line of length $\lambda_l$. **Figure 3** shows the field configuration for a strip conductor that is above a conducting plane separated by a dielectric sheet.

The signal arising from a frequency shift, S, to input power, P, can be calculated from the following equation:[3]

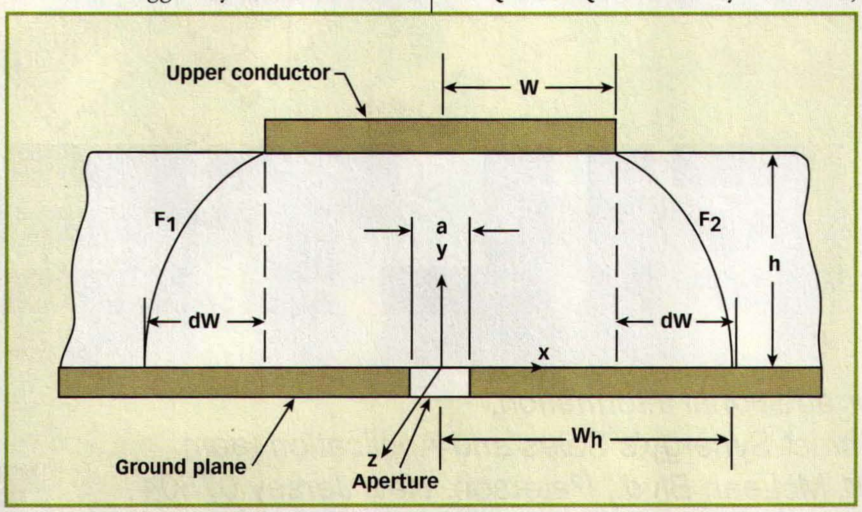
$$S/P = 0.163\ (W_o/W_m)Q \qquad (1)$$

where:

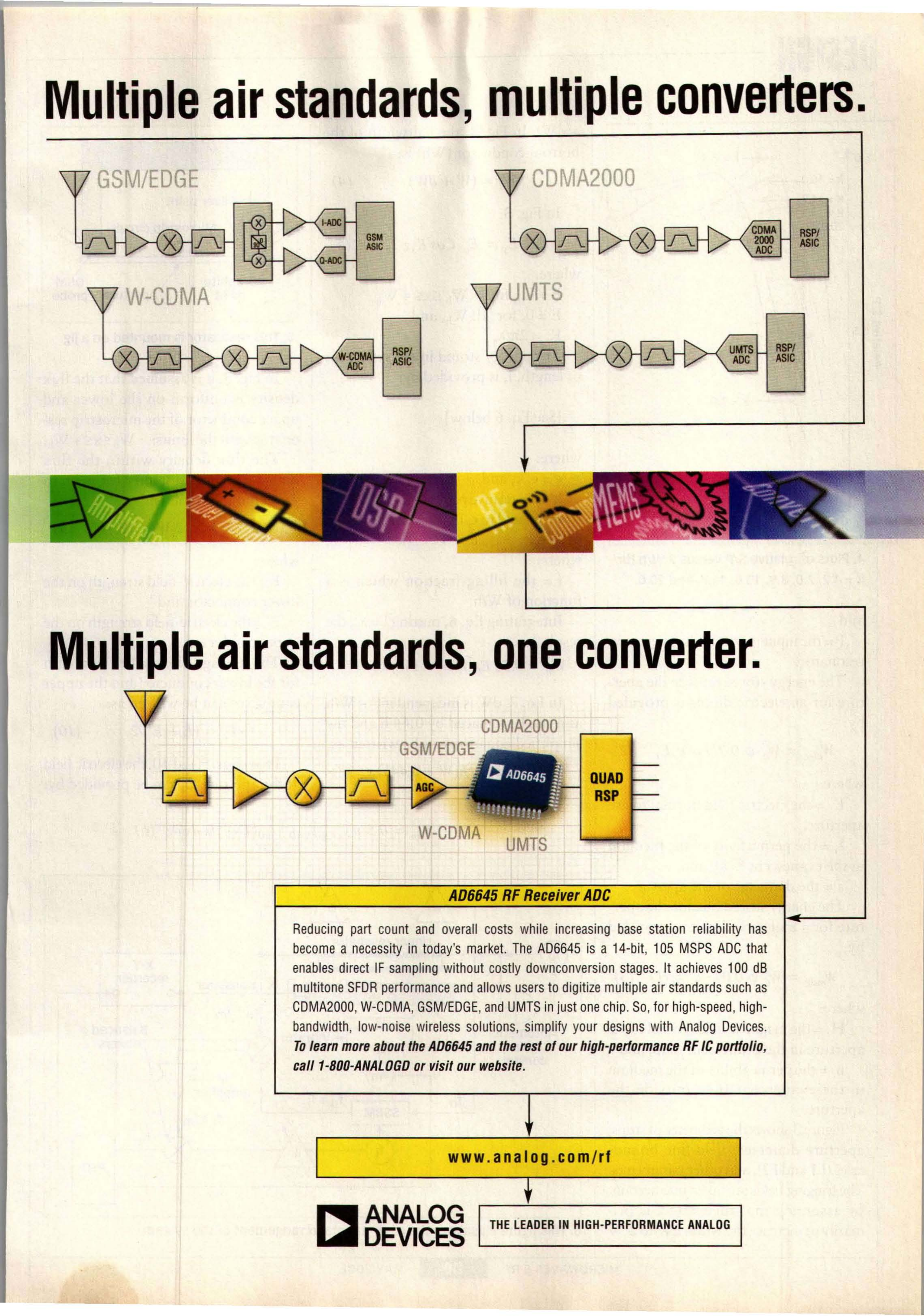
$W_m$ = the energy stored in the microstrip resonator,

$W_o$ = the energy stored in the evanescent field outside the aperture,

Q = the Q of the cavity resonator,




**3. Field configuration and dimensions of a microstrip resonator are shown here.**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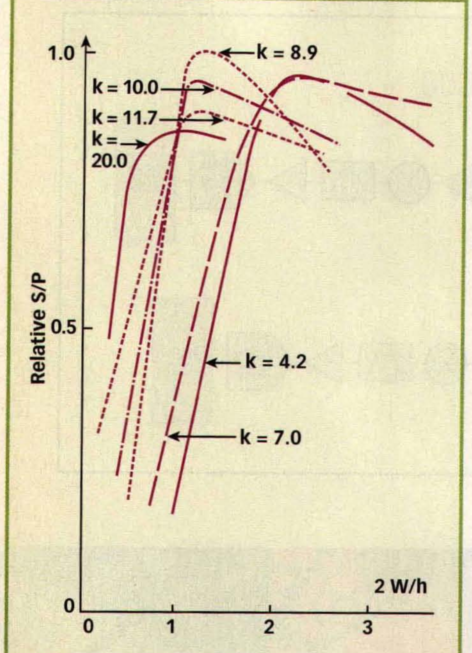



**4. Plots of relative S/P versus 2 W/h for k = 4.2, 7.0, 8.9, 10.0, 11.7, and 20.0.**

and

P = the input power to the microstrip resonator.

The energy stored outside the aperture for an electric dipole is provided by:

$$W_{elec} = W_o\ \varphi\ 0.011 a^3 \varepsilon_r E_1 \quad (2)$$

where:

$E_1$ = the electric field normal to the aperture,

$\epsilon_r$ = the permittivity of the medium in the evanescent field, and

a = the diameter of the aperture.

The energy stored outside the aperture for a magnetic dipole is provided by:

$$W_{mag} = W_o\ \varphi\ 0.043\ a^3 \lambda_r H_1 \quad (3)$$

where:

$H_1$ = the magnetic field normal to the aperture in the evanescent field, and

$\mu_r$ = the permeability of the medium in the evanescent field outside the aperture.

Figure 3 shows the geometry of strips, aperture diameter, field-line boundaries (F1 and F2), and other parameters. The fringing fields are taken into account by assuming that their effect is primarily to increase the width 2W to 2(W + dW). In Fig. 3, the halfwidth of the bottom conductor (Wh) is:

$$W_h = (W + dW) \quad (4)$$

In Fig. 3:

$$E_y = E_o\ Cos\ K_s z \quad (5)$$

where:

$E = E_o$, for $-W_h \leq x \leq +W_h$,

$E = 0$, for $|x| > W_h$, and

$K_s = 2\pi/\lambda_s$

The energy stored in the resonator of length, l, is provided by:

[See Eq. 6 below]

where:

$\epsilon = \epsilon_o k$, and

k = the relative permittivity of the substrate related to $\epsilon_r$ by Wheeler's relation of $\epsilon_r = 1 + f(k - 1)$ where:

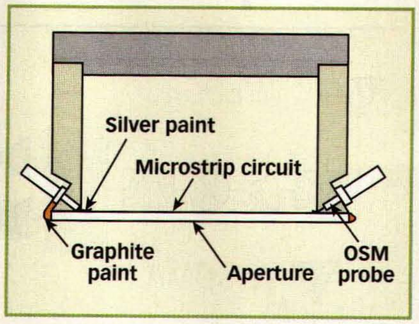
f = the filling fraction which is a function of W/h.

Integrating Eq. 6, putting $l = \lambda_s$, the result is:

$$W_m = 0.5\varepsilon\, E_0^2 h(W + dW)\kappa_s \quad (7)$$

In Eq. 7, dW is independent of W/h and can be replaced by 0.44 h and the simplified equation can be written as:

$$W_m = 0.5\varepsilon\, E_0^2 h(W + 0.44h)\kappa_s \quad (8)$$




**5. This resonator is mounted on a jig.**

In Fig. 3, it is assumed that the flux density is uniform on the lower and upper conductor of the microstrip resonator with the limits: $-W_h \leq x \leq +W_h$.

The flux density within the flux boundaries does not alter for y = h to y = 0 and the result is:

$$\kappa_s 2WE = \kappa_s 2(W + dW)E' \quad (9)$$

where:

E = the electric-field strength on the lower conductor and

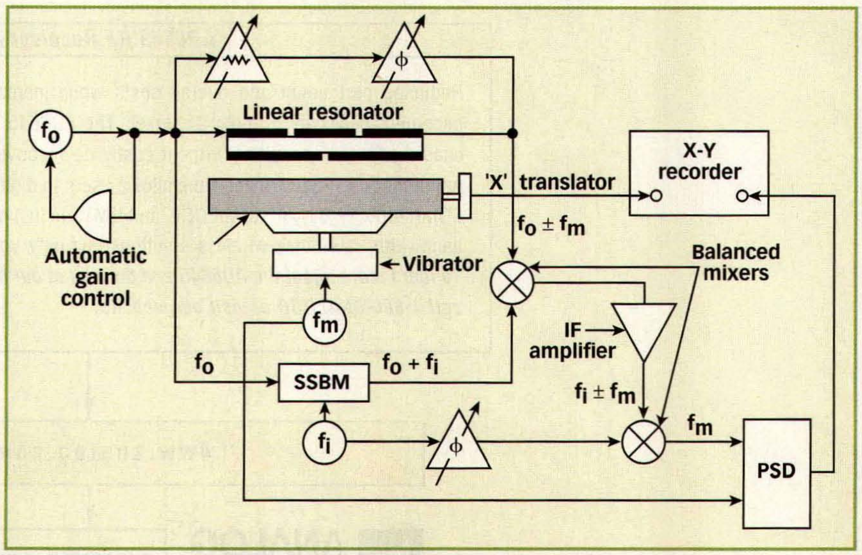
E' = the electric-field strength on the upper conductor.

The average electric-field strength for the lower conductor and the upper conductor can be written as:

$$E_o = (E + E')/2 \quad (10)$$

From Eqs. 9 and 10, the electric field at the aperture $E_1$ can be provided by:

$$W_m = 0.5\ \varepsilon \int_{x=g} \int_{y=0} \int_{z=0} (Ey)^2\, dx\, dy\, dz \quad (6)$$




**6. This figure illustrates the experimental arrangement of the system.**

$$W_m = \left(0.011 a^3 \varepsilon^2 E_o^2 W^2\right) / \left[o \left(W + dW\right)\right]^2 \quad (12)$$

$$S / P = \left\{\left(0.03\, a^3\, Q\, W^2\right) / \left[o\, \kappa \left(\varepsilon_r\right)^{1/2} h^3\right]\right\} \times \left\{1 / \left[\left(W/h + 0.22\right)^2\right] \times \left[\left(W/h\right) + 0.44\right]\right\} \quad (13)$$

$$E' = \left(E_o\, W\right) / \left[W + \left(dW/2\right)\right] \quad (11)$$

From Eqs. 8 and 11, one can write:

[See Eq. 12 above]

From Eqs. 1, 2, and 12, one can obtain:

[See Eq. 13 above]

From Eq. 13, it is concluded that for large S/P, there is a need to increase Q and W/h, while decreasing $\epsilon_r$ and h. For a particular h, a decrease in $\epsilon_r$ increases the characteristic impedance $Z_o$ and, hence, changes the Q. It can be shown that for h = 0.25 mm, the signal-to-power ratio is more than the maximum obtained for h = 0.625 or 1.25 mm. Consequently, h is set to the minimum value of 0.25 mm, for which experimental results are available. **Figure 4** shows plots of relative S/P versus 2 W/h for k = 4.2, 7.0, 8.9, 10.0, 11.7, and 20.0. The S/P ratio is calculated at 10 GHz and an aperture diameter of 300 μm. The optimum parameter of a linear microstrip resonator can be summarized as: h = 0.25 mm, 2 W/h = 1.25 ±0.25, k = 9 ±1, $Z_o$ = 45 ±4 Ω, S/P = 0.5 × $10^{-4}$.

The microstrip resonator is fabricated on a copper (Cu)-coated alumina substrate using conventional photolithographic techniques. The surface finish of the substrate is better than 10 μm to ensure low-loss performance. The aperture for evanescent mode is in the bottom of the microstrip. **Figure 5** shows a microstrip resonator mounted on a jig, to provide freedom to scan large samples beneath the aperture plane. To stop electromagnetic (EM) leakage near the input and output probes, silver (Ag) paint was used inside and graphite paint was used outside.

The imaging property of the present instrument may be explained by studying the change in the energy stored in the vicinity of the aperture by the sample. It is assumed that the aperture fields are represented by an electric dipole that modifies Eq. 2 as:

[See Eq. 14 on p. 114]

where:

$\epsilon_{rd}$ = the relative permittivity of the material placed below the aperture.

In Eq. 14, terms in the brackets are constant and it can be rewritten as:

$$W_o \propto \varepsilon_{rd} \qquad (15)$$

**Figure 6** shows the experimental arrangement of the system for the measurement of the permittivity of materials. RF energy from a microwave signal generator (fo) is fed to the microstrip resonator. An attenuator and a phase shifter are adjusted in the bridge circuit to suppress the carrier and avoid over-

$$U_{elect} = W_o = \left(0.011a^3\varepsilon_r\ E_1\right)\varepsilon_{rd} \qquad (14)$$

loading the first mixer. A sample is placed on the vibrator. The vibrator operates at a frequency of fm and the output is connected to the first input of the phase-sensitive detector (PSD). A signal at a frequency of fo ±fm passes through a balanced mixture and an intermediate-frequency (IF) amplifier. Finally, a signal (fm) goes to the second input of the PSD from the balanced mixture. The single-sideband modulator (SSBM) is modulated with a local oscillator (LO) at a frequency of fi and produces an output of fo + fi.

The evanescent-field technique provides an accurate value of permittivity, which is scanned for polystyrene and Plexiglass samples. It has been possible to measure relative permittivity of artificial samples of normal and cancerous (tumor cells) skin. Improved software can be developed to show the actual image. MRF

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| S4W2 | S4W5 | N4W5 | 4 | ±0.40 |
| S5W2 | S5W5 | N5W5 | 5 | ±0.40 |
| S6W2 | S6W5 | N6W5 | 6 | ±0.40 |
| S7W2 | S7W5 | N7W5 | 7 | ±0.60 |
| S8W2 | S8W5 | N8W5 | 8 | ±0.60 |
| S9W2 | S9W5 | N9W5 | 9 | ±0.60 |
| S10W2 | S10W5 | N10W5 | 10 | ±0.60 |
| S12W2 | S12W5 | N12W5 | 12 | ±0.60 |
| S15W2 | S15W5 | N15W5 | 15 | ±0.60 |
| S20W2 | S20W5 | N20W5 | 20 | ±0.60 |
| S30W2 | S30W5 | N30W5 | 30 | ±0.85 |
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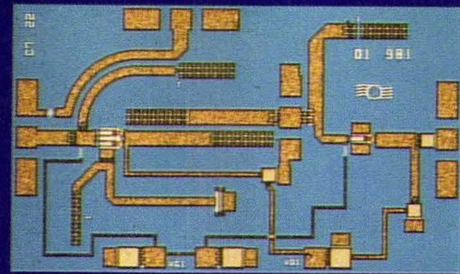

DESIGN

# TD-SCDMA Txs Hone Base-Station Efficiency

TD-SCDMA multicarrier Txs do not come without their challenges, but there is a solution available that is based on existing products.

**Base-station transmitters (Txs) handling symmetric and asymmetric services require high-bandwidth efficiency. Time-division-synchronous code-division multiple access (TD-SCDMA) supports these services through the use of time-division duplex (TDD), enabling alternate uplink and downlink transmissions on the same radio carrier by periodically switching the direction of transmission.[1] The bene**fit is that the switching point between the downlink and uplink directions can be set to a symmetric relation in reference to symmetric services or a range of asymmetric values for asymmetric services. In this way, TDD offers improved spectrum usage and traffic capacity for both types of service.

TD-SCDMA employs a combination of frequency-division-multiple-access (FDMA), time-division-multiple-access (TDMA), and CDMA techniques. Coupled with smart antennas that support dense spectrum reuse, TD-SCDMA enables efficient use of the radio spectrum.[2]

TD-SCDMA-based systems satisfy third-generation (3G) requirements (high data rates for new intensive applications, packet-oriented transmission, and new mobile Internet applications) and let operators benefit from a smooth and low-risk migration from second generation (2G) to 3G. The combination of demand for lower-cost 2G systems and the initial deployment of 3G systems encourages base-station man-

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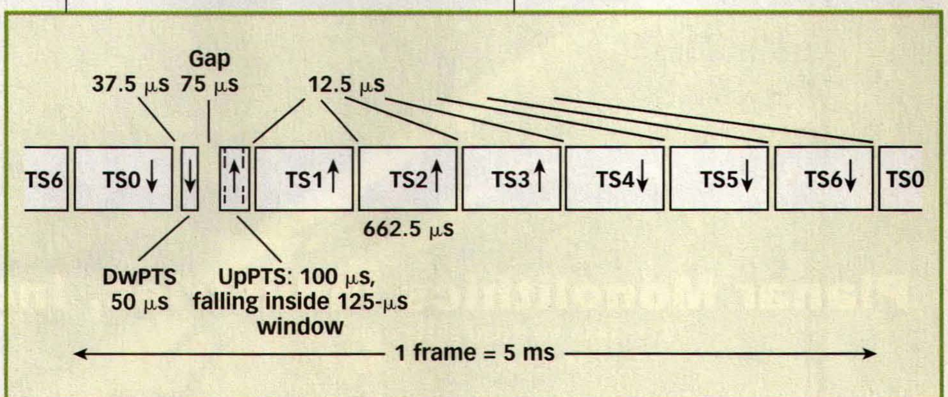
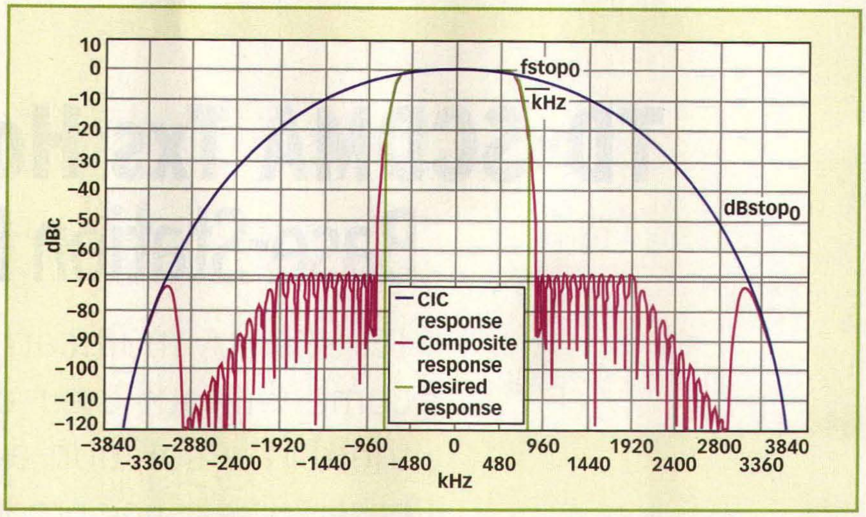



**1. The 5-ms frame consists of seven time slots as uplink and downlink directions that are depicted by arrows.**

ufacturers to adopt new reconfigurable hardware platforms. Many base-transceiver-station (BTS) manufacturers see a multicarrier transceiver as achieving a solution for supporting wireless air-interface standards in a single infrastructure design.

Classic base-station architectures require a complete transceiver for every RF carrier processed (from four to 80 channels for digital and analog systems, respectively). These radios must be multiplied for diversity. The beauty of a multicarrier transceiver is the elimination of redundant radios in favor of a single, high-performance radio per antenna where each RF carrier is processed in the digital domain.




**2. This figure shows the AD6623 frequency response of a filtered TD-SCDMA carrier.**

Radio-access networks (RANs) based on TD-SCDMA radio transmission can be connected to Global System for Mobile Communications (GSM) core systems, offering seamless integration of 3G-like services and functionality in existing GSM networks. This will enable GSM operators to upgrade in a cost-efficient way to 3G, since the costs of overall integration and reuse of GSM core-network infrastructure are factors in deciding the economic case for 3G.

The physical structure of a frame is shown in **Fig. 1**. The 5-ms frame is composed of seven time slots as uplink and downlink directions that are depicted by arrows. TS0 is always downlink and TS1 is always uplink. Contrary to the usual

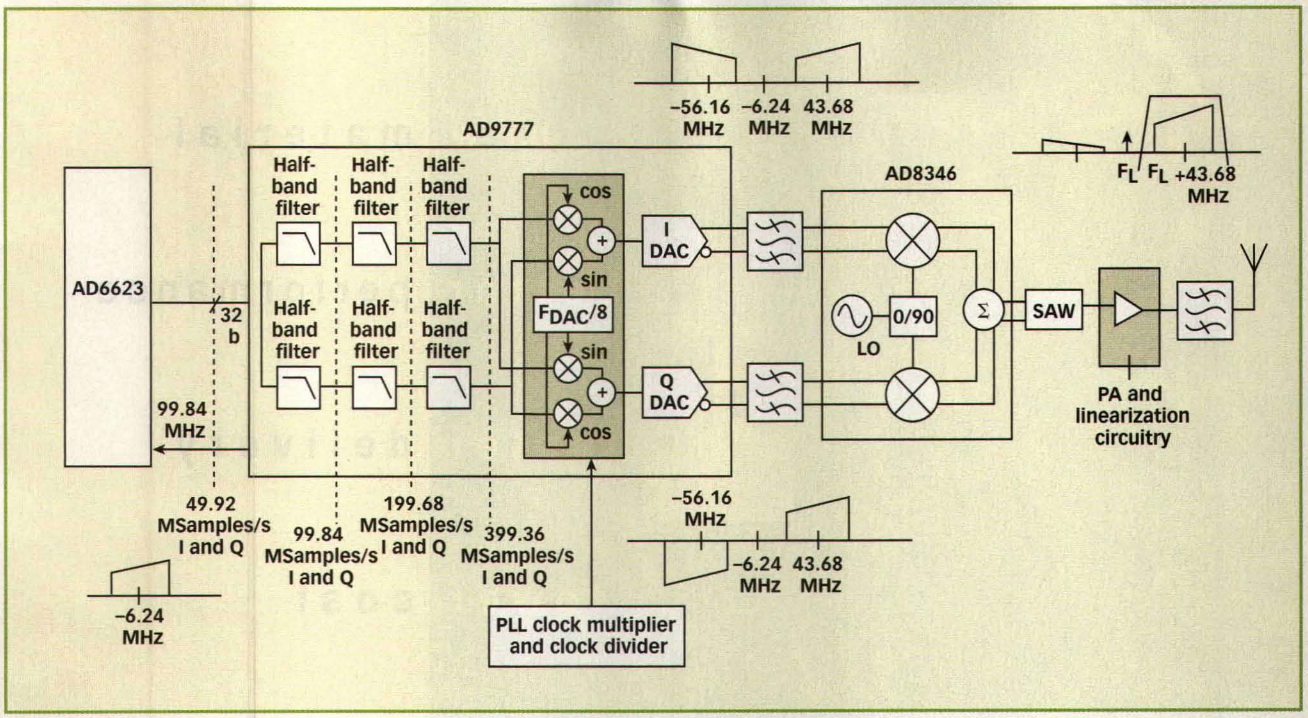
representation, the net lengths of the time slots can be seen without the adjacent guard periods.[3] The switching point between uplink and downlink can be between TS1/TS2 and TS6/TS0, and there is a guard period of only 12.5 µs. After TS0, there is a downlink pilot signal DwPTS used for synchronization of the UEs. The UpPTS of 100 µs for random access and synchronization is sent by the UE, and should fall into the designated 125-µs window. It is, however, possible that it already arrives during the leading gap, so that the BTS controller (BTSC) must be in receive state as early as possible. This gap is occasionally used for calibration purposes.

The TD-SCDMA radio interface is integrated by 3GPP as the low-chip-rate option of UTRA-TDD, UTRA-TDD LCR. The high-chip-rate mode will appear as UTRA-TDD HCR (3.84-Mchips/s chip rate, 5-MHz bandwidth). The symbol duration is $T_s$ = Q ($T_c$, where Tc = 1/chip rate = 0.78125 _s, the symbol time $T_s$ depends upon the spreading-factor Q. The modulation scheme is quadrature phase-shift keying (QPSK). The pulse-shape filtering is applied to each chip at the Tx. The impulse response of the pulse-shape filter h(t) shall be a root-raised cosine with a roll-off factor of $\alpha = 0.22$. The corresponding raised-cosine impulse h(t) is defined as:

$$h(t) = \frac{\sin \pi \frac{t}{Tc}}{\pi \frac{t}{Tc}} \times \frac{\cos \alpha\pi \frac{t}{Tc}}{1 - 4\alpha^2 \frac{t^2}{Tc^2}} \quad (1)$$

Digital-to-analog converters (DACs) and multicarrier power amplifiers (MCPAs) must preserve the spectrum of several digitally generated carriers without corruption or spurious signal generation in adjacent channels. A base-station Tx must generate minimal spectral regrowth on the individual carriers and as a result of intermodulation (IM) between the carriers. A DAC that can generate higher frequencies enables a reduction of upconversion stages from two to one. Unfortunately, converter performance deteriorates at higher frequencies.[4] Multicarrier transmission differs from single-carrier radios, which rely on analog filters to remove undesired signals that could corrupt adjacent channels. Instead, multicarrier architectures must inherently limit distortion over the entire transmission bandwidth.

When an RF PA carries a signal that does not have a constant envelope, a group of carriers, or the sum of several CDMA signals, the PA generates IM distortion (IMD). Since the IM power falls into adjacent channels as interference, advanced wideband PA linearization schemes have become a key technology in multicarrier transceivers.




3. A three-carrier TD-SCDMA Tx block diagram is shown here.

According to the 3GPP standard, a TD-SCDMA Tx should be designed for coexistence of TD-SCDMA BTS with GSM and DCS-1800 BTSs. To lower the linearity requirements for the MCPA, the adjacent-channel-leakage-ratio (ACLR) specification for the DACs shall not exceed the values specified in **the table.**

The peak-to-average power ratio (PAPR) of the TD-SCDMA signal depends on the number of codes and carriers. Maximum PAPR occurs if all codes and carriers add in phase.

The AD6623 is a four-channel 104-MSamples/s transmit signal processor (TSP) that suits multimode wireless base-station Tx architectures. It is used between digital signal processors (DSPs) and high-speed DACs in a base-station Tx. The dynamic range of a 16-b DAC allows many AD6623 summed channels to be

**ACLR frequency offset and minimum requirement**

| OFFSET FROM CENTER FREQUENCY (MHz) | MAX. BTS ACLR VALUE (dBc) |
|---|---|
| ±1.6 | –55 |
| ±3.2 | –63 |
| ±4.8 | –63 |

transmitted over several megahertz of bandwidth where the PAPR is high, with an average output signal level at a fraction of the full-scale range. Also, the programmable coefficient finite-impulse-response (FIR) filter stage allows anti-imaging and static equalization functions to be combined in a single, cost-effective filter. The programmable power-ramp up/down unit supports power ramping on a time-slot basis as specified for TD-SCDMA.

The range of interpolation factors in each Cascaded Integrator Comb (CIC) filter stage and a resampler incorporated into a second-order CIC filter make the AD6623 useful for creating narrowband and wideband carriers in a high-speed sample stream. The high-resolution numerically controlled oscillator (NCO) supports flexibility in frequency planning. The high-speed NCO can tune a quadrature-sampled signal to an intermediate-frequency (IF) channel, or the NCO can be directly frequency modulated at an IF channel.

The AD9777 is the 16-b high-performance, programmable 2×/ 4×/8× interpolating Tx data converter (TxDAC) for baseband or IF waveform reconstruction, requiring high dynamic range. AD9777 features a serial port interface (SPI), providing a high level of programmability, thus supporting enhanced system-level options including:

- Selectable 2×/4×/8× interpolation filters.
- $F_s/2$, $F_s/4$, or $F_s/8$ (where $F_s$ is the sampling frequency of the AD9777) digital quadrature modulation with image rejection.
- A direct IF mode; programmable channel gain and offset control.

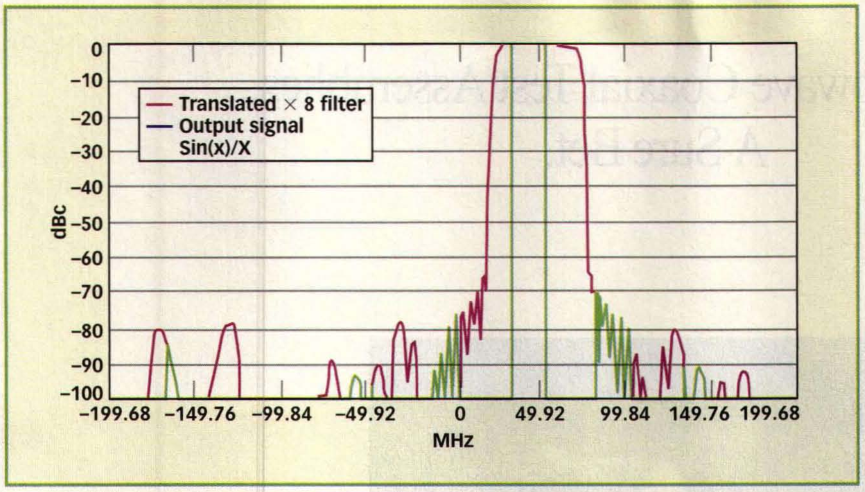
AD8346 is a silicon (Si) RF integrated-circuit (IC) in-phase/quadrature (I/Q) modulator for use from 0.8 to 2.5 GHz. Its phase accuracy and amplitude balance allow high-performance direct modulation to RF.

This Tx subsystem complements Analog Devices ADSP TS001M TigerSHARC™ DSP. This DSP is for communications applications that are capable of performing two billion 16-b multiply/accumulates per second at 200 MHz.

The highest integer oversampling of the TD-SCDMA chip rate below 400 MHz is 399.36 MHz (1.28 × 39 × 8.0 Mchips/s). The objective of the AD6623 filter is to constrain the output signal bandwidth so that it remains below the transmit mask defined for TD-SCDMA. The baseband signal has a chip rate of 1.28 Mchips/s. The digital upconverter running with $f_{CLK}$ = 99.84 MHz performs the root-raised cosine filtering, interpolation, and frequency shifting. Up to three TD-SCDMA carriers can be placed within a band of 20 MHz. The serial data source drives data at $f_{SCLK} = f_{CLK}/2$ = 40.96 Mb/s (or 1.28 × 32.00 = 40.96 Mb/s) per AD6623 processing channel. This configuration is nearly optimal for the AD6623. The master clock runs at 99.84 MHz, allowing the programmable FIR filter to calculate 39 taps.

$$N_{FIR} = \frac{f_{CLK}}{f_{IN}} \times \frac{1}{2} \qquad (2)$$

The programmable coefficient FIR filter interpolates the input signal by a fac-




**4. Three filtered TD-SCDMA carriers at the AD9777 output are located anywhere in the blue rectangle.**

tor of 3 and precompensates for the CIC filter roll-off in the passband. The RAM-coefficient (RCF) output rate is 3.84 MSamples/s per processing channel. The second filter stage, a fifth-order CIC (CIC5) filter, provides an interpolation of $L_{CIC5} = 13$. The CIC5 output rate is 49.92 MSamples/s. The third filter stage, a second-order resampling CIC, does not provide any interpolation of ($L_{rCIC2} = 1$). The CIC2 output rate is 49.92 MSamples/s (complex samples). The CIC and NCO save power by running at the complex rate of 49.92 MHz. The interpolated TD-SCDMA signal is upconverted to an IF = −6.24 MHz by a sine/cosine sequence generated by the NCO and the carriers are shifted by the AD6623 to a frequency band of −16.24 MHz...3.76 MHz. **Figure 2** presents the AD6623 composite transfer function with 0.116-dB passband ripple and a stop-band at 0.87 MHz.

The expected error vector magnitude (EVM) must be less than 2 percent for all filters. The EVM is calculated by observing the time-domain impulse response of the actual AD6623 filter matched by a root-raised-cosine (RRC) receive filter. Since a suitable RRC has an infinite response, a large number of symbols are used to ensure that no significant error vectors are aliased by the Fourier Transform, which would result in an inaccurate measurement. This is verified by noticing the small results in the center of the impulse response plot. The calculated $EVM_{rms}$ is 0.47 percent.

AD9777 accepts interleaved I/Q data from AD6623 **(Fig. 3)**. The data interface is 32 b wide, 16 b for the real, and 16 b for the imaginary part. AD9777 generates a complex modulated IF signal with its dual DACs, which is translated to RF through an analog quadrature modulator. The image-rejection and frequency-shift capability of the DAC determine the requirements of the following analog filter stages. The AD9777 interpolates the data by $L_{DAC} = 8$ resulting in a sample rate to 399.36 MSamples/s. This configuration allows the 43-tap first-stage filter to run at 399.36/8 = 49.92 MHz. The TD-SCDMA carriers span 33.68 to 53.68 MHz. The band is centered to an IF of 43.68 MHz (49.92 × 7/8 MHz). **Figure 4** shows a blue rectangle and, in it, three filtered TD-SCDMA carriers at AD9777 output can be located.

In the quadrature modulator that follows AD9777, two mixers operate in quadrature. The mixer outputs are summed internally to perform mathematical operations according to phase relationships and signs of the frequency components. MRF

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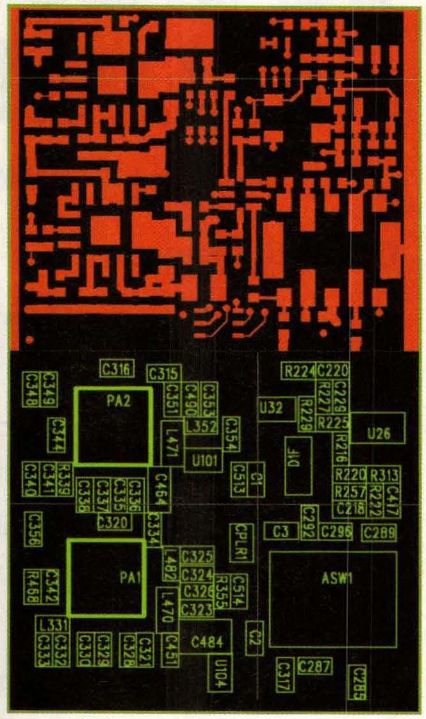
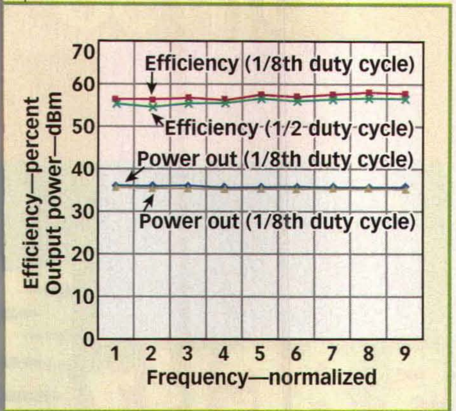
an antenna. In most practical RF systems, the PA's power level is quite high and considerable DC power is consumed in the process of amplification.[3] In base-station or household applications, the amount of available energy is generally unlimited, and the amount of power consumed by the PA is, therefore, not critical as long as the transmitted signal reaches the required power level. In a handset, however, the available energy is limited, so the power consumed by all devices, especially in the PA, must be minimized to extend the useful operating time for a set of charged batteries.[4-6]



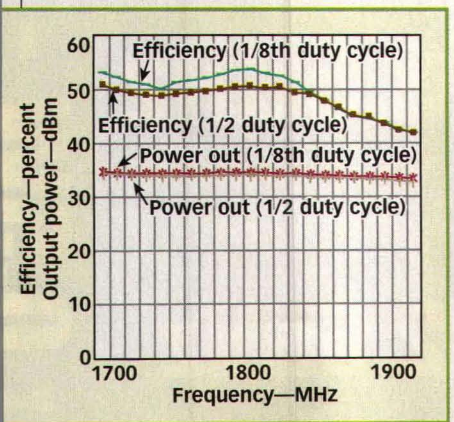
3. The dual-band cellular/PCS PA was fabricated on low-cost FR4 PCB material.

Recently, a broadband matching technique was developed based on the use of photonic bandgap (PBG) structures with microstrip circuitry. A PBG structure is a form of periodic structure that exhibits a specific stopband. Because the stopband is generally wider than that of a quarter-wavelength stub, PBG structures are well-suited for impedance matching in broadband high-efficiency amplifiers.[7] By achieving the highest-possible efficiency, of course, the size and weight of an amplifier can be minimized for a particular output power, while also minimizing power consumption and improving overall reliability.

Many different types of high-efficiency PAs, such as Classes AB, B, E, and F, have been reported in the literature using various bias schemes.[8] A variety of different amplifier semiconductor technologies are also available for constructing high-efficiency amplifiers. GaAs HBT technology is one of the best technology candidates for realizing a GSM PA, since the HBT supports single-voltage operation and delivers high power density with good lineari-




**4. These measured results show the output power and efficiency levels of the dual-band amplifier at GSM-900 frequencies.**




**5. These results show the output power and efficiency levels of the dual-band amplifier at DCS-1800 frequencies.**

ty and high efficiency.[9,10] In fact, the GaAs HBT technology can also be applied for coverage of the DCS-1800 band by using a PA design incorporating modules for the GSM-900 and DCS-1800 bands coupled with a front-end switch. The main task of the dual-band PA is to amplify the modulated Gaussian minimum-shift-keying (GMSK) signal to the required (defined) power level, minimize spurious signals, and maintain high efficiency. The combination of the RFMD RF2173 and RF2174 modules made possible the dual-band GSM/DCS design. The dual-band coupler and power-sensing diode and front-end switch module complete the PA circuit **(Figs. 1 and 2)**. The front-end switch incorporates a lowpass filter to attenuate the strong spurious signals. The PA fits on an FR-4-based PCB measuring less than 17 × 20 mm; the PCB includes the analog-power-control (APC) circuitry, the two PA modules, and the front-end switch **(Fig. 3)**.

For a GSM mobile unit, spurious emissions should meet type approval according to the ETSI 11.10 specification. According to ETSI 11.10, section 12.1, out-of-band spurious emissions above 1 GHz should be less than −30 dBm. For the RF2173 PA module, for example, the second harmonics reach a

worst-case level of −38 dBc. So, from a system-level point of view, an additional 27-dB attenuation is needed to bring these spurious emissions into agreement with the ETSI specification. This is the reason for including the lowpass filter with the front-end switch to attenuate this strong source of spurious emissions.

One of the more-stringent requirements for a GSM transmitter (Tx) is dynamic range, which should exceed 59 dB. When the Tx is not in operation, the output power should be less than −54 dBm for GSM and −48 dBm for DCS. From a system-level point of view, signals from the temperature-compensated, voltage-controlled crystal oscillator (TCVCXO) at the input of the PA are between +4 to +8 dBm. According to the specifications, 2-W output power is needed at the GSM antenna port and 1-W output power at the DCS antenna port. When the automatic-power-control circuitry and the front-end switch are taken into account, the RF2173 should deliver +35-dBm output power, while the RF2174 should deliver +32-dBm output power.

**Figures 4 and 5** show the performance levels of the designed PA for use in GSM 900 and DCS 1800 applications, respectively. Under a normal condition of +3.6-VDC supply and 50-Ω matching load, the PA design is capable of delivering output power of +35 dBm and PAE of 55 percent in a GSM system, along with output power of +32 dBm and PAE of 50 percent in a DCS system, respectively. As can be seen from the performance levels of Figs. 4 and 5, the high-efficiency amplifier design offers a competitive advantage over most modules on the market. MRF

**ACKNOWLEDGMENTS**

The authors wish to thank vice-president Michael Wang and the Wireless Business Unit (WBU) of Quanta Computer Inc. (Taiwan, ROC) for their valuable suggestions and encouragements during this work.

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## Wireless LAN Standards and Applications

*by Asuncion Santamaria and Francisco J. Lopez-Hernandez, editors*

*Wireless LAN Standards and Applications* provides and overview of wireless systems and standards. The contents point readers to updated information on the Internet, providing the Web addresses of the main regulation and standardization organizations and listing the websites of technological alliances driving the evolution of wireless technology. The book provides a practical understanding of the latest WLAN standards and their implementation. It clearly explains the two principal standards, IEEE 802.11 and IrDA, as well as the HiperLAN standard, and explores their real-world applications through commercially available equipment. Specific scenarios explain how WLAN systems can be built and integrated with cabled systems.

Chapter 1 introduces WLANs, the need for standardization, and future trends. Topics include home-cell environments for in-house applications, picocell environments for in-building systems and applications, microcell environments for applications covering urban areas, and the global environment for applications using satellite-based systems. Chapter 2 include a general description of IrDA standards, reviews of SIR physical-layer specifications, serial IrLAP, IRDA LrLAP, and a review of connectionless services and connection-oriented services.

The IEEE 802.11 standard is introduced in Chapter 3. Subjects include MAC for the IEEE 802.11 WLANs, physical layer for IEEE 802.11 WLANs and IR systems, and a review of conclusions and applications. Chapter 4 reviews the HiperLAN standard. HiperLAN is a set of WLAN communication standards that are primarily used in European countries. There are two specifications: HiperLAN/1 and HiperLAN/2. Both have been adopted by the ETSI. Other topics include HiperLAN CAC and MAC as well as future BRAN standards.

Chapter 5 reviews application scenarios, WLAN technology and products, the IR market and a list of component manufactures and mobile computing products. Standards and future trends are discussed in Chapter 6. Subjects include an introduction to the future of wireless, the evolution of HiperLAN and IEEE 802.11 standards, forthcoming IR standards, and other RF standards including DECT, Bluetooth, and HomeRF. (2001, 234 pp., hardcover, ISBN: 0-89006-943-3, $85.00.) **Artech House, 685 Canton St., Norwood, MA 02062; (781) 769-9750, FAX: (781) 769-6334, Internet: www.artech-house.com.**

## Test a GAIT Phase One mobile telephone

GAIT PHASE ONE mobile telephones integrate TDMA and GSM voice and data technologies into a single handset featuring the capability to choose and operate with either a TDMA or GSM network. Telephones using GAIT Phase One technology will offer uses the capability of choosing and then using either a GSM or TDMA network. GAIT mobile phones enable roaming on other networks and disallow intrasystem handsoffs and handovers. Based on an internal lookup table that is known as the NSDB, the mobile phone will recognize its own primary operator and will thus be able to decide on its own whether to operate on either a TDMA or GSM network. This ability is based on parameters that are programmed within the mobile system's NSDB, which can be found on the GAIT mobile's revised SIM card. These parameters, along with other features of GAIT mobile phones, are explained for testing purposes by Rob Barden, Senior Product Marketing Manager for IFR (Wichita, KS), in his 10-page application note, "Testing GAIT Phase One Mobiles."

With the GAIT phone, one is required to test for GSM and TDMA RF performance. The note describes GSM mobile Tx test parameters such as power level, RMS phase error, peak phase error, frequency error, bit timing, and power profile conformance. For GSM mobile Rx test parameters, BER1, BER2, RBER1b, RBER2, and FER are detailed. TDMA mobile Tx test parameters, such as power level, error-vector magnitude, frequency error, and adjacent-channel power, are described. TDMA mobile Rx BER testing is explained.

Explanations of each GAITmode is included, along with changes to protocol testing procedures and a thorough breakdown of what is involved with NSDB testing. Discussions on how to put the test system together, how to set up GSM and TSDMA test processes, and how to test for GHOST are provided. Tips on creating a new GSM SMS PDU and how to make international emergency calls on the GAIT mobile without requiring network registration are offered.

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*Keeping resistance constant results in an underdamped system as well as increased overshoot and ringing.*

## Reduce parasitic inductance in a 10-Gb/s optical Tx

OPTICAL TX DESIGN at 10 Gb/s requires strict attention to the sources and effects of parasitic inductance if it is to be successful. Inductance of 0.1 nH or higher can be the catalyst for degradation in Tx rise/fall times, overshoot/ringing, and jitter in the optical output. This theory is put to the test in a three-page application note from Maxim Integrated Products (Sunnyvale, CA) entitled "Parasitic Inductance Effects in the Design of 10Gbps Optical Transmitters" by the Maxim High-Frequency/Fiber Communications Group. By simulating an optical Tx design, the authors attempt to pinpoint factors that would be the downfall of Tx design in a real-world situation.

The driver-modulation output transistor needs a minimum specified voltage to switch correctly. The design simulation uses a minimum voltage requirement of +1.55 VDC at the modulation output. Operation below this minimum can cause suboptimal transistor switching that will increase jitter and other distortions to the optical output. Parasitic inductance is a major factor in reducing voltage headroom during switching.

Neglecting the effects of parasitic capacitance and assuming a simplified STC model, the authors calculate a rise/fall time using the L/R time constant. In the simulation, a 20-to-80-percent rise time is calculated, yielding a result that, while not exact, provides an idea of the approximate level of inductance that can be tolerated without disrupting rise/fall times.

Keeping resistance constant results in an underdamped system as well as increased overshoot and ringing. However, if the resistance is increased, the headroom can be impacted negatively. The trick to keep the circuit critically damped and headroom requirements met, say the authors, is to keep parasitic inductance minimized. This note is available as a free download from the company's website at www.maxim-ic.com.

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| • Gali 4F | DC-4000 | 14.3 | 13.4 | ±0.5 | 15.3 | 4.0 | 32 | 93 | 50 | 4.4 | 1.29 |
| • Gali 51F | DC-4000 | 18.0 | 15.9 | ±1.0 | 15.9 | 3.5 | 32 | 78 | 50 | 4.4 | 1.29 |
| • Gali 5F | DC-4000 | 20.4 | 17.4 | ±1.5 | 15.7 | 3.5 | 31.5 | 103 | 50 | 4.3 | 1.29 |
| • Gali 55 | DC-4000 | 21.9 | 18.5 | ±1.7 | 15.0 | 3.3 | 28.5 | 100 | 50 | 4.3 | 1.29 |
| • Gali 52 | DC-2000 | 22.9 | 17.8 | ±2.5 | 15.5 | 2.7 | 32 | 85 | 50 | 4.4 | 1.29 |
| • Gali S66 | DC-3000 | 22 | 17.3 | ±2.4 | 2.8 | 2.7 | 18 | 136 | 16 | 3.5 | .99 |
| Gali 6 | DC-4000 | 12.2 | 11.8 | ±0.3 | 18.2 | 4.5 | 35.5 | 93 | 70 | 5.0 | 1.49 |
| Gali 4 | DC-4000 | 14.4 | 13.5 | ±0.5 | 17.5 | 4.0 | 34 | 93 | 65 | 4.6 | 1.49 |
| Gali 51 | DC-4000 | 18.1 | 16.1 | ±1.0 | 18.0 | 3.5 | 35 | 78 | 65 | 4.5 | 1.49 |
| Gali 5 | DC-4000 | 20.6 | 17.5 | ±1.6 | 18.0 | 3.5 | 35 | 103 | 65 | 4.4 | 1.49 |

■ Low frequency cutoff determined by external coupling capacitors. † Measured in test fixture P/N 90-6-20-26.
▲Models tested at 2GHz except Gali 4, 5, 6, 51, 52, 6F, 4F, 51F, 5F at 1GHz.
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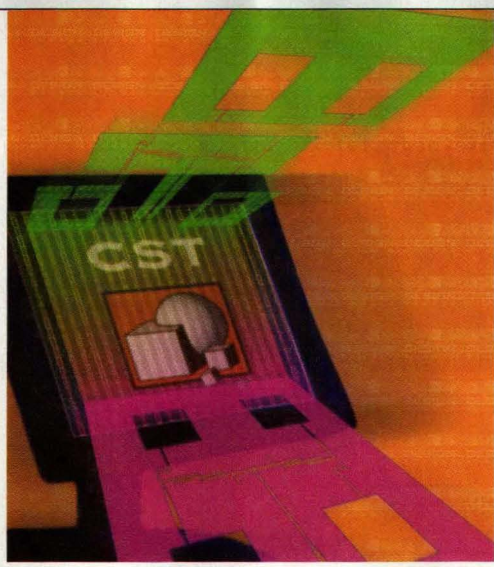


# Open Architecture Solves Large 3D Puzzles

Version 2.0 of CST's Design Studio modeling environment allows the seamless interaction of any number of solvers and simulation tools, as well as models and test data.

**Higher speeds and increasingly complex designs are blurring traditional boundaries between system modeling approaches. Complex computations are often best-solved by breaking them into a series of related, smaller problems. That is the approach used in Version 2.0 of the CST Design Studio (CST DS) from CST (Wellesley,** MA), an open design environment that allows a variety of electronic-design-automation (EDA) tools to be applied to different parts of circuit and system models. With the open environment, a design engineer is free to choose the most-appropriate solvers available, regardless of the simulation method or supplier.

The open environment also makes it possible to take advantage of available expertise, enabling integration of solutions from measurements, empirical approaches, analytic or semi-analytic methods, or solutions from numeric solvers of any kind. The CST DS supports the seamless integration of these different techniques within a single unifying framework.

The framework enables the creation of reusable parts with its fully parameterized, user-extendable and user-definable library of elements and blocks. When a numerical simulation is performed, it is stored for future refer-

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**Application Engineer**
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ence in a data base. If the required solution for a particular parameter set is not available when a simulation is performed, a new simulation will be launched. Any number of solvers can be made available for a simulation, with the fastest and most appropriate solver used for all of the constituent parts of a system. The fully parameterized parts offer an easy route to optimization and parameter studies.

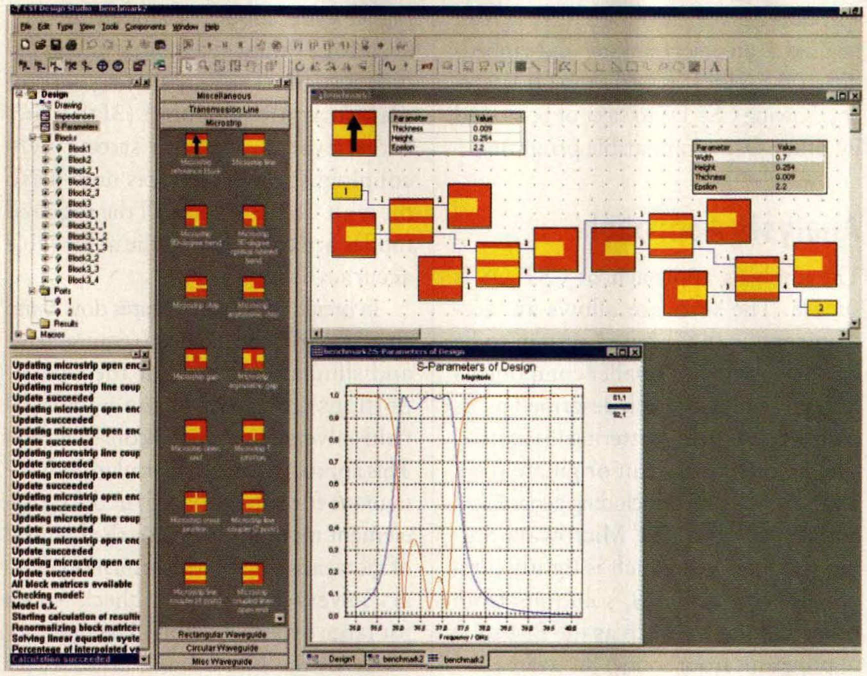
CST DS makes full use of a Visual Basic for Applications (VBA)-compatible macro language. An integrated VBA interface builder (including a VBA editor and macro debugger) enables effective customization of the software. CST DS features a native graphical user interface (GUI) based on Microsoft Windows 95/98/NT/2000. In particular, the component-object-model (COM) interface enables seamless integration of a variety of software tools, including Matlab and Microsoft Excel, or even specialized proprietary tools. CST DS can be used as an object-linking-and-embedding (OLE) client, as well as an OLE server (allowing CST DS to steer or be steered by other OLE-compatible programs).

## Analysis Approach

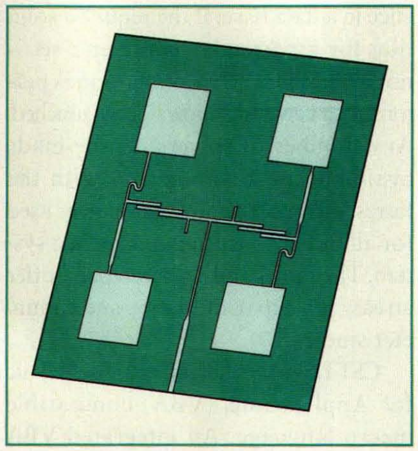
The analysis approach of CST DS is simple. The software allows an electromagnetic (EM)-based system to be broken down into smaller components known as blocks, each described by its own (generalized) scattering (S) matrix. The S-matrix data can originate from a variety of sources, including generalized S-matrices from CST Microwave Studio (CST MWS) which is tightly integrated with CST DS, solutions from other simulators, such as the EM suite of programs from Sonnet Software (Liverpool, NY), or files from other programs, such as Touchstone.

CST DS can also take into account higher-order modes or mode coupling, even for evanescent modes in waveguide systems. The partitioning of complex three-dimensional (3D) structures, even those with strong field coupling such as filters, is now feasible with CST DS, since all the required modes are coupled and the achievable accuracy is high.

In breaking large structures down into smaller parts, the memory requirements and simulation time (for the smaller portions) for most of the numerical field solvers are reduced considerably. This approach can be particularly advantageous for solvers based on the finite-element method (FEM) or the method of moments (MOM) where memory-hungry solvers can be kept in check—even for large overall systems. The memory usage of the Finite Integration Technique (FIT) solver used in CST MWS is more modest and scales linearly with the number of elements used for the




1. Using the reference-block capability of CST DS, the key parameters of a microstrip filter can be set globally, with the highlighted parameter (the width of a single stripline) controlled individually.



2. This microstrip patch antenna includes a patch-antenna array and associated feed network. It can be broken into smaller parts to simplify simulation.

discretization of a 3D geometrical model. However, there is still a large advantage to concentrating an optimization on only a small part of a structure rather than resimulating the whole system for each new optimization parameter.

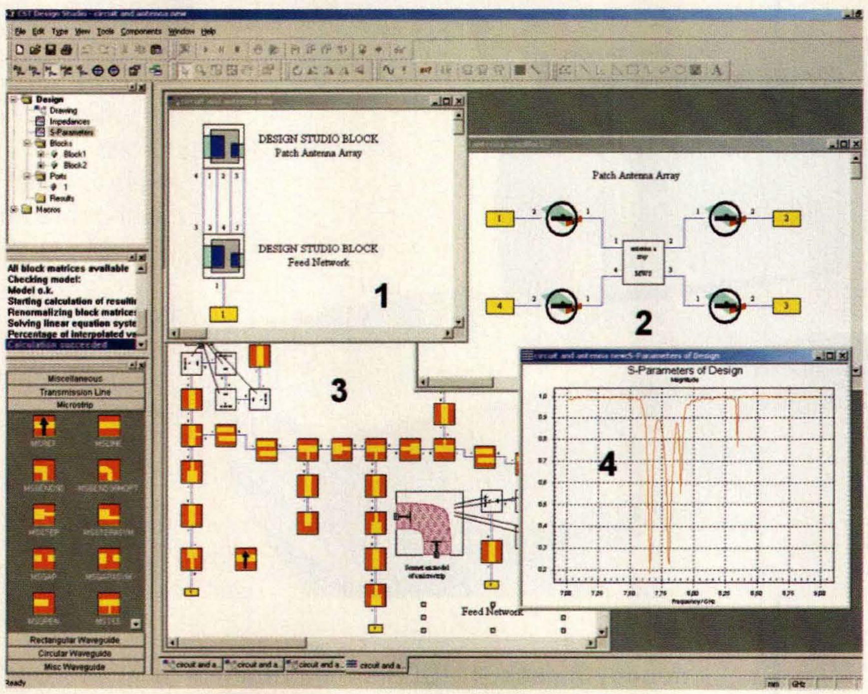
## Parameter Sweep

Version 2.0 of CST DS features improvements in all aspects of the code. The software now features a quasi-Newton-type optimizer, which enables a faster approach to an optimum solution over the conventional steepest-descent approach. Integration of the "parameter sweep" technique is also greatly improved compared to Version 1.0, making parameter studies of an arbitrary number of variables much more straightforward.

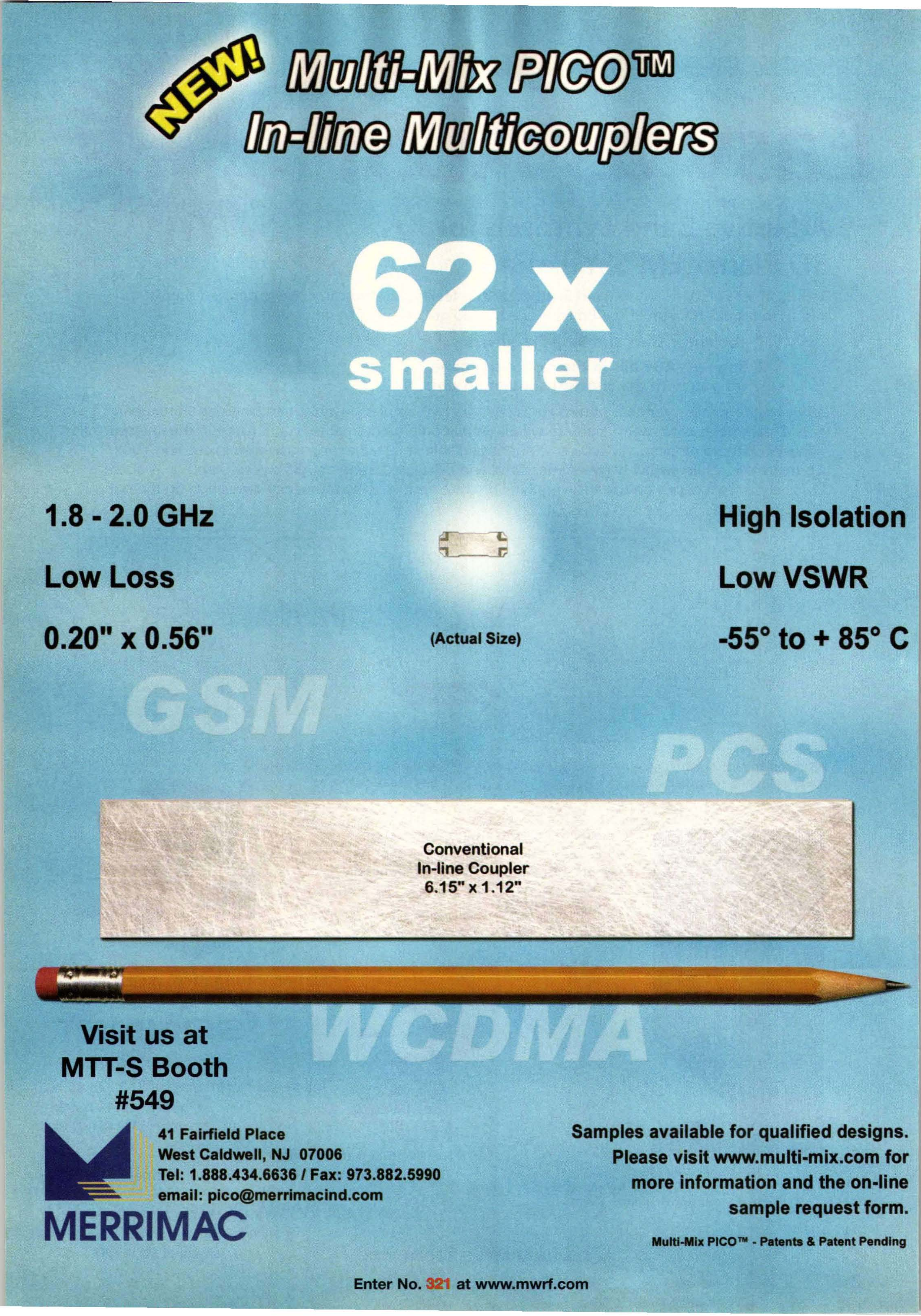
"Blocks" are the fundamental elements used in CST DS to design a system. The range of these blocks has been significantly extended in Version 2.0 by the inclusion of predefined library elements. A block can be a parameterized model of a structure that will be solved numerically in 3D, or it can be a third-party solution from another simulator. A block can also be based on measurements from a vector-network analyzer (3D) or tables of S-parameter data.

The library of available elements is greatly augmented by access to CST MWS blocks. The results for all previously used parameter sets are stored in a data base so that only new parameter sets require new numerical simulations. This "solver-on-demand" approach and re-use of existing data cuts down central-processing-unit (CPU) requirements considerably.

One of the new elements is the De-embedding Block. Using it, a user is allowed to ignore arbitrary circuit parts, in particular the influence of connectors




3. This screen shot shows the CST DS representation of the patch antenna of Fig. 2 as two Design Studio blocks and an external feed (window No. 1).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and transitions. This new feature also makes the inverse behavior of a Block available. So, using an appropriate De-embedding Block, which may be either analytical or simulated, arbitrary inner ports of a microwave structure may be accessed and the electromagnetic behavior of the attached components and their interaction may be studied.

More complex, hierarchical structures can be created through the use of "Design Studio blocks." A Design Studio block can contain fundamental blocks, as well as further Design Studio blocks. These complex structures can be created within CST DS or loaded from a file. All the details of a complex system can be contained within these Design Studio blocks.

## Reference Blocks

"Reference blocks" are used within CST DS to represent the common properties of a larger number of blocks. As an example, **Fig. 1** shows a microstrip filter where the reference-block metallization and substrate thickness, as well as the substrate permittivity is set with values for the whole structure. The properties of each block can be displayed using labels (such as the Parameter label) used in Fig. 1. In this example, the width of a single stripline is highlighted as the only parameter that can be adjusted individually. All of the other parameters are set globally within the reference block.

The GUI in Version 2.0 has also been markedly improved. The GUI features a Microsoft Outlook-like control bar (the center left portion of Fig. 1) which enables rapid construction of a complex structure out of predefined blocks using "drag-and-drop" techniques. The control bar is extendable by user-defined library elements, which can be illustrated with the built-in bitmap editor.

Tight integration with CST MWS enables the synthesis of systems incorporating planar and 3D structures. For example, **Fig. 2** shows a microstrip patch antenna including the antenna array and associated feed network. The complete system behavior is of interest, as well as the behavior of the feed network and the resulting radiation characteristics of the antenna array. A straightforward approach to this problem using a 3D EM field solver requires a very fine grid resolution everywhere to accurately simulate the radiation from the patch antennas, as well as the edge-coupled filters.

**Figure 3** shows the CST DS representation of the four patch antennas and the feed network. At the uppermost level (window No. 1 in Fig. 3) this system is represented by only two Design Studio

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blocks and an external feed. Double-clicking on the upper Design Studio block opens the model that lies beneath, in this case the patch-antenna array (window No. 2 in Fig. 3). The main element in this patch-array subsystem is a fully parameterized CST MWS block containing the patch antennas without the feed network. This Design Studio block provides the S-parameter of the complete antenna array, including coupling between the single antennas. The far-field behavior of the complete array is available through CST MWS.

To derive the S-matrices of the patch array without taking into account the feed-network, additional power sources must be included in the CST MWS model. Since these artificial elements should not influence the simulation results, they are subtracted in CST DS from the CST MWS S-matrix through the use of the de-embedding blocks (marked in Fig. 3 by the large minus signs that surround the CST MWS block). The use of the de-embedding-block functionality of CST DS makes the creation of arbitrary inner ports in a 3D model possible.

In this example, the de-embedding blocks are realized by a user-defined parameterized library element. Changing any of the parameters will trigger a new simulation run if the results are not already accessible through the data base. The results for this subsystem (as well as those of every single block) are available within the software and so the optimization of subsystems is straightforward.

The second Design Studio block (window No. 3 in Fig. 3) contains the planar feed circuit. It is mostly built with analytic blocks from the CST DS element library. Sonnet EM models provide the system description of the meander lines. The CST DS model is fully parameterized, taking advantage of a reference block to set the common parameters for the planar circuit. The feed circuit was optimized to the design frequency range.

Finally, the broadband system response of the whole circuit is derived (Window No. 4 in Fig. 3). The overall system can now be optimized. The signal phase and amplitude on the antenna ports can be fed into CST MWS to derive the array far-field characteristics for the particular configuration.

Version 2.0 of CST DS brings numerous improvements to all aspects of the program. Version 2.0 is currently available for a variety of operating systems, including Windows 95/98/NT/2000. CST of America, Inc., 8 Grove St., Suite 203, Wellesley, MA 02482; (781) 416-2782, FAX: (781) 416-4001, e-mail: info@cst-america.com, Internet: www.cst-america.com.

**Enter No. 51 at www.mwrf.com**

# Demodulator Extends Range Of Telemetry Systems

This PCM/FM demodulator improves detection efficiency in airborne telemetry systems by 3 dB.

**MICHAEL RAUF**
**Wireless Data Products Manager**
Nova Engineering, Inc., 5 Circle Freeway Dr., Cincinnati, OH 45246-1201; (513) 642-3000, FAX: (513) 642-3374, e-mail: sales@nova-eng.com, Internet: www.nova-eng.com.

**PCM/FM is the modulation scheme of choice in most airborne telemetry systems. In other applications, it is simply referred to as binary FM, or BFSK. To take advantage of the large installed base of systems, Nova Engineering (Cincinnati, OH) has developed the Hypermod FMD11 demodulator for improved detection efficiency. The demodulator, which supports data rates from 1 to 11 Mb/s, provides 3-dB** better performance than the best previously available PCM/FM demodulators.

The new demodulator features a standard 70-MHz IF interface, an integral-bit synchronizer, and a real-time FM eye-pattern display on the front panel. Typically, demodulators of this type have the eye-pattern output in the back of the unit, which requires the connection of other equipment, such as an oscilloscope, for monitoring. The integral-bit synchronizer provides a synchronized clock signal at the demodulator's output ports, along with the demodulated data.

When using conventional methods, adding 3 dB to detection efficiency required either doubling the Tx power (resulting in a larger box and more heat to dissipate) or doubling the receive-antenna area (raising costs). In contrast and in a departure from traditional single-symbol techniques, the FMD11 uses a multiple-symbol detection algorithm for enhanced data recovery, analyzing the received signal across several symbols to recover the data. This approach takes advantage of the "memory" inherent in a PCM/FM waveform.

Upon examining the waveform, for instance, approximately 80 percent of the energy is centered in one symbol, but it is also affected by the adjacent symbols. By considering five symbols, approximately 90 percent of the otherwise-ignored energy can be harvested to yield 3-dB better performance than a single-symbol approach.

The Hypermod FMD11 implements the multisymbol demodulation technique through an advanced FPGA architecture. The use of multiple Virtex 2000E FPGAs from Xilinx, Inc. (San Jose, CA) helps to improve performance for current systems, and to also provide enough headroom to support multiple demodulation schemes into the future.

The rack-mountable Hypermod FMD11 measures 19 × 16 × 3.5 in. (48.26 × 40.64 × 8.89 cm). P&A: $24,500.00; 6 to 8 wks. **Nova Engineering, Inc., 5 Circle Freeway Dr., Cincinnati, OH 45246-1201; (513) 642-3000, FAX: (513) 642-3300, e-mail: sales@nova-eng.com, Internet: www.nova-eng.com.**

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# Compact Components Handle High Power

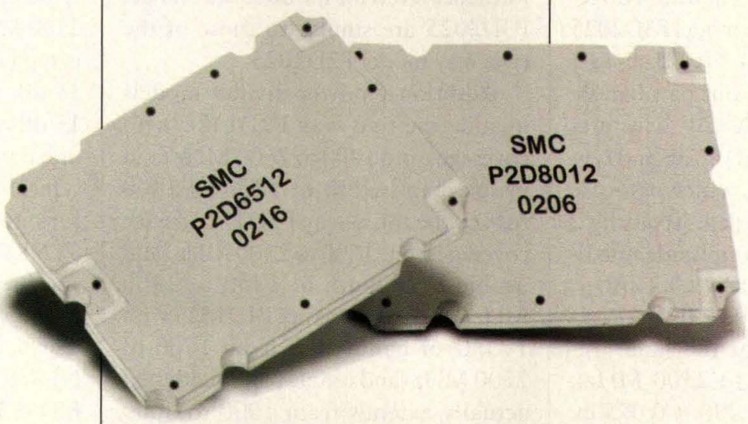
SYNSTRIP multilayer circuit technology is the basis for a new line of miniature hybrid power dividers with low insertion loss and excellent phase/amplitude characteristics.

**JACK BROWNE**
**Publisher/Editor**

**Multilayer circuit technologies help shrink the size of traditional microwave passive components, such as power dividers and couplers, without sacrificing performance. A case in point is a new line of power dividers from Synergy Microwave Corp. (Paterson, NJ) based on the firm's innovative SYNSTRIP multilayer circuit technology (see "Technology Delivers High-Performance Components,"** ***Microwaves &*** *RF*, June 2000, p. 131). Although barely larger than packaged transistors, these tiny components can handle power levels in excess of 10 W at cellular and personal-communications-services (PCS) frequencies.

SYNSTRIP technology offers miniaturization far beyond the limits of conventional microstrip technology. The approach employs a mixed-mode propagation concept where different transmission media are employed to optimally distribute a wideband signal through different layers of a circuit. In a conventional microstrip power divider, meandering lines are unavoidable, leading to unwanted coupling between lines and discontinuities. To achieve reasonable performance, the coupling effects must be accurately modeled and accounted for in the final design. The meandering lines required in conventional microstrip circuits are eliminated, minimizing the effects of unwanted coupling and discontinuities. Due to the small size of SYNSTRIP components, amplitude and phase unbalances are minimal, with tight tolerances between divider arms.

For example, model P2D8102 **(Fig. 1)** is a two-way power divider designed for Advanced Mobile Phone Service (AMPS) and Global System



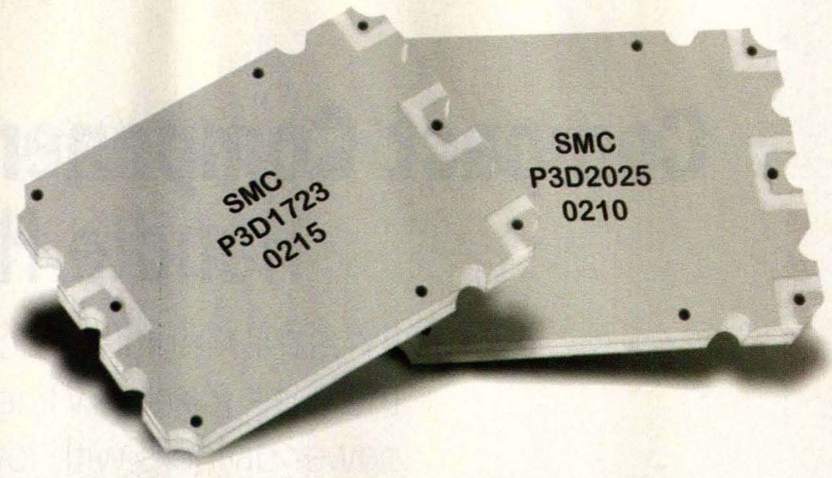

**1. The P2D8012 and P2D6512 are two-way SYNSTRIP power dividers designed for bands of 800 to 1200 MHz and 650 to 1250 MHz, respectively.**

for Mobile Communications (GSM) applications from 800 to 1200 MHz. It measures only 0.650 × 0.480 × 0.065 in. (1.65 × 1.22 × 0.17 cm), but handles continuous-wave (CW) power levels to 10 W courtesy of typical insertion loss of only 0.2 dB. The power divider achieves at least 20-dB isolation, with typical performance of 25 dB. The tiny component features maximum phase unbalance of 2 deg. (typically 1 deg.) and worst-case amplitude unbalance of ±0.4 dB (typically ±0.2 dB). The typical VSWR is 1.30:1.

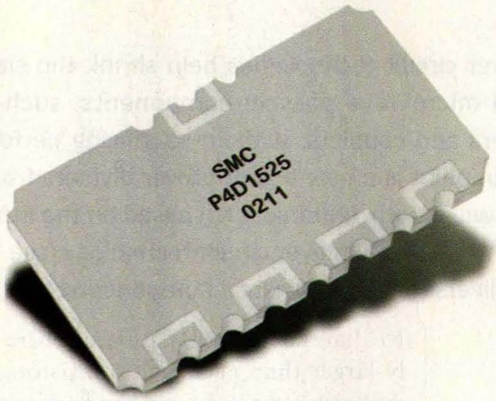
Similarly, model P2D6512 is a two-way power divider with a range of 650 to 1200 MHz (and usable bandwidth of 500 to 1500 MHz). It also measures just 0.650 × 0.480 × 0.065 in. (1.65 × 1.22 × 0.17 cm), but can handle CW power levels to 10 W thanks to typical insertion loss of 0.20 dB and maximum insertion loss of 0.35 dB. The isolation between channels is at least 15 dB and typically 25 dB. The phase unbalance is no worse than 0.4 deg. and typically 0.2 dB, while the amplitude unbalance is ±0.4 dB maximum and typically ±0.2 dB.

For higher-frequency applications, two-way power-divider model P2D2025 operates from 2000 to 2500 MHz with 0.3-dB typical insertion loss and 25-dB typical isolation. It fits in the same footprint as the P2D8102 and also handles power levels up to 10-W CW, with similar phase and amplitude-unbalance performance. For applications over that same frequency range requiring a three-way power divider, the model P3D2025 measures 0.650 × 0.480 × 0.075 in. (1.65 × 1.22 × 0.19 cm), but can handle power levels up to 10-W CW. It features typical insertion loss of 0.2 dB and typical isolation of 25 dB, with worst-case phase unbalance of 3 deg. (typically 2 deg) and worst-case amplitude unbalance of ±0.3 dB (typically ±0.2 dB).

The model P3D2025 **(Fig. 2)** is a three-way version for the same frequency range (2000 to 2500 MHz), measuring 0.650 × 0.480 × 0.075 in. (1.65 × 1.22 × 0.19 cm) and handling input-power levels up to 20 W. The typical insertion loss is 0.2 dB (maximum of 0.3 dB), while the typical isolation is 25 dB (minimum of 18 dB). The phase and amplitude-unbalance performance levels for the three-way model P3D2025 are similar to those of the two-way model P2D2025.




**2. The P3D2025 and P3D1723 are three-way SYNSTRIP power dividers designed for bands of 2000 to 2500 MHz and 1700 to 2300 MHz, respectively.**




**3. The P4D1525 is a four-way SYNSTRIP power divider with low insertion loss and high isolation from 1500 to 2500 MHz.**

Additional power-divider models include the two-way P2D1426 with coverage from 1400 to 2600 MHz (and usable bandwidth of 1200 to 2800 MHz), the three-way P3D1723d with coverage from 1700 to 2300 MHz (and usable bandwidth of 1400 to 2400 MHz), and the four-way P4D1525 with 1 GHz of bandwidth from 1500 to 2500 MHz (and usable bandwidth that actually extends from 1000 to 3000 MHz). The model P2D1426 features maximum insertion loss of 0.4 dB (and typically 0.2 dB), with minimum isolation between branches of 15 dB (and typically 25 dB). The phase unbalance is typically 0.2 deg. and no worse than 0.3 deg., while the return loss is at least 14 dB and typically 20 dB.

The three-way model P3D1723d features insertion loss of 0.5 dB or less (and typically 0.4 dB) above normal splitting losses, from 1700 to 2300 MHz **(Fig. 3)**. It achieves at least 18 dB isolation and typically 28 dB isolation, with return loss of better than 18 dB and typically as good as 28 dB. The phase unbalance is typically 1 deg. and no worse than 2 deg. across the full operating band.

The four-way model P4D1525 offers maximum insertion loss of 0.7 dB (and typically only 0.4 dB) from 1500 to 2500 MHz. The isolation between arms is typically 20 dB and nor worse than 15 dB, while the return loss is at least 15 dB and typically 25 dB. The phase unbalance is no worse than 3 deg. and typically better than 2 deg. The performance levels for all of these new SYNSTRIP power-divider models are specified for operating temperatures from −55 to +85°C. **Synergy Microwave Corp., 201 McLean Blvd., Paterson, NJ 07504; (973) 881-8800, FAX: (973) 881-8361, e-mail: sales@synergymwave.com, Internet: www.synergymwave.com.**

**Enter No. 53 at www.mwrf.com**

# WDM Couplers Cut Optical Losses

These nearly lossless devices are one of the basic building-block components for CWDM optical-communications systems.

**Coarse-wavelength-division-multiplexing (CWDM) technology began life in the early 1980s as a means of transporting digital video signals over multimode optical fiber. Used primarily in cable-television (CATV) links, CWDM technology now offers a great deal of promise for high-speed digital communications in existing fiber-optic communications systems. In support of the technology, a new supplier to** the market, MVS Optical Systems (Danbury, CT), has developed an innovative manufacturing approach to produce low-loss WDM components, including WDM couplers. The performance of these components helps improve the performance and extend the range of existing optical data links.

**FLOYD PARIN**
**President**
MVS Optical Systems, 87B Sand Pit Rd., Danbury, CT 06810; (203) 792-7474, FAX: (203) 792-7475, e-mail: mvsmicro@att.net, Internet: www.micronetics.com.

The MVS Optical Systems' WDM couplers each consist of two sections of standard single-mode optical fiber fused lengthwise. The fused fibers are tapered and elongated using a computer-controlled manufacturing process that does away with the need for additional optical structures, such as gratings.

The couplers provide channel separation from 4 to 35 nm, with less than 0.25-dB typical excess optical signal loss. The typical isolation between channels is better than 20 dB. The couplers exhibit outstanding thermal stability with less than 0.01-nm change in channel wavelength from −50 to +80°C.

The couplers can be used as two-port multiplexers (muxs), demultiplexers (demuxs), or as bidirectional devices. They can be cascaded to form four- and eight-channel CWDM mux/demux modules with 40- and 20-nm respective channel separation. The 20-nm separation enables the combination and separation of up to eight communications channels over a single fiber at wavelengths from 1470 to 1610 nm providing, for example, a cost-effective upgrade from a single-channel system to a four- or eight-channel system. The couplers allow a fiber-link capacity limited at 2.4 Gb/s to be upgraded to 10 Gb/s.

By using a cascaded four-port multiplexer/demultiplexer coupler pair with four low-cost ML9XX19 indium-gallium-arsenide (InGaAs) distributed-feedback (DFB) laser diodes from Mitsubishi (Sunnyvale, CA), data rates to 10 GB/s can be achieved over a single strand of optical fiber. A typical four-channel mux/demux module using the MVS Optical Systems' couplers yields typical insertion loss of less than 0.25 dB with more than 25-dB channel isolation. **MVS Optical Systems, 87B Sand Pit Rd., Danbury, CT 06810; (203) 792-7474, FAX: (203) 792-7475, e-mail: mvsmicro@att.net, Internet: www.micronetics.com.**

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# Digitizer Family Characterizes High-Speed Signals

A family of waveform digitizers with large acquisition memories sets the standard for speed, density, and power-consumption performance levels.

**PETER STAVENICK**
Managing Editor

**Digitizers do not usually take on the characteristics of oscilloscopes. Digitizer models DC211, DC241, and DC271 from Acqiris (Monroe, NY), however, feature sampling rates as fast as 4 GSamples/s with more than 1-GHz bandwidth and 8-b resolution. Combined with generous acquisition memories, these compact (233 × 160-mm) digitizers can do the job of much larger sampling oscilloscopes. With a PC, the** user has the option of using software to determine rise time, fall time, as well as overshoot.

The digitizers' low power consumption results in a 28-channel at 1-GSamples/s or seven-channel at 4-GSamples/s system that uses comparable power to most high-end four-channel digital oscilloscopes. This family of instruments uses Windows-based software to support adjustment of key acquisition settings including time base, trigger, and sensitivity, while state-of-the-art front-end electronics support high-fidelity recording with control of input impedance, coupling, gain, and offset. Data recorded by the digitizers can be transferred directly to a host PC at rates to 100 MB/s.

Digitizer model DC211 is a single-channel 1-GHz, 8-b, 4-GSamples/s waveform digitizer that features an acquisition memory of 512 kpoints to 32 Mpoints. The model DC241 dual-channel digitizer offers 1 GHz, 8 b, 2 GSamples/s, and 4 GSamples/s in single channel from 256 kpoints to 16 Mpoints per channel. Model DC271 is a waveform digitizer that features 1 GHz, 8 b, and 1 GSamples/s in quad channel and 2 GSamples/s in single channel with 128 kpoints to 8 Mpoints per channel.

The digitizers feature a typical VSWR of 1.25:1 at DC to 1 GHz, 50-Ω impedance of ±1 percent at DC, maximum input voltage of ±5 VDC, and a typical long-term settling time of 10 ns at 1 percent of the step frequency. With 700-, 200-, and 20-MHz bandwidth-limit filters, differential linearity is at ±0.7 LSB.

Each digitizer has its own crystal-controlled time base. Sample rates can be chosen in a 1.0, 2.0, 2.5, 4.0, and 5.0 sequence, ranging from 100 Samples/s to 4 GSamples/s. The sample rate can also be generated externally by using the external input connector for those applications where the sample rate and the signal need to be acquired. An internal TTI with high timing resolution assists with timing calibration and trigger positioning. P&A: $9990 to $14,990. **Acqiris USA, P.O. Box 2203, 234 Cromwell Hill Rd., Monroe, NY 10950; (877) 227-4747, FAX: (845) 782-4745, Internet: www.acqiris.com.**

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# Waveform Analysis Is Forte Of Digital Storage Scope

## A totally redesigned oscilloscope platform is outfitted to mathematically analyze today's complex waveshapes, rather than to simply view them.

**PETER STAVENICK**
**Managing Editor**

**Communication-system signals are becoming so fast and complex that the simple viewing and measuring of time and voltage on an oscilloscope screen are no longer adequate to understand a circuit's operation. To deal with this new reality, the data present in a signal must be re-presented to a designer through waveshape analysis. This is the aim of the LeCroy (Chestnut Ridge, NY) WaveMaster 8500 digital** storage scope, an instrument that was completely redesigned in hardware and software to capture high-speed (up to 5 GHz) signals and analyze them with an architecture known as X-Stream, which eliminates the trade-offs between storing long records and fast processing.

X-Stream hardware uses advanced SiGe signal-acquisition ICs that track an incoming signal, digitize it at 10 GSamples/s on four input channels, and send the data to a CMOS acquisition memory that can store up to 48 million points of acquisition. The effective sampling rate can be increased to 20 GSamples/s if only two input channels are used. Data arriving from the signal-acquisition ICs are packetized and transferred in a real-time streaming mode over a 100-Mb/s bus directly into the CPU's cache memory. The newly designed software platform allows instructions and calculations to be performed in the cache. This enables data to be processed many times faster than if it were stored in conventional RAM. Much of the power and speed of X-Stream technology stems from this ability to simultaneously store data packets and measurement routines in the WaveMaster 8500's CPU cache memory.

**LeCroy's WaveMaster 8500 scope is optimized to analyze complex signals using math and measurement tools.**

Waveshape analysis sets the WaveMaster 8500 apart from competing digital oscilloscopes. Standard features include a total of 38 parameter measurements and 28 math functions. However, users can customize the instrument with their own math functions and parameters. A new feature is the "Histicon," which is a display of icons or snapshots of parameter histograms. It permits a user to quickly visualize the performance of key signals and focus on the source of signal problems as revealed by the Histicon shapes.

The user interface offers three modes of controlling the Pentium-3-based scope: the familiar front-panel-controls type, touch screen, and a mouse (in any combination). The screen is 10.4-in. (26.42-cm) TFT SVGA with 800 × 600 pixel resolution **(see figure)**. The instrument includes a 100BaseT Ethernet LAN connection. **LeCroy, 700 Chestnut Ridge Rd., Chestnut Ridge, NY 10977-6499; (800) 553-2769, Internet: www.lecroy.com.**

**Enter No. 56 at www.mwrf.com**

# VCO-Core Chip Solves Module Size, Cost Problems

Developed to simplify multiband VCO module designs, this VCO-core IC is able to operate across multiple wireless standards and frequencies.

**JACK BROWNE**
Publisher/Editor

**VCOs used in multiband wireless handsets can present designers with a difficult trade-off—IC sources are low in cost but may compromise performance, while modularized, discrete-component types perform well but have size and cost drawbacks. Circumventing this dilemma is a broadband VCO-core IC, the IBM3100, from IBM Microelectronics (Lowell, MA), enabling manufacturers of discrete VCO modules** to provide handset designers with a middle-of-the-road path. When used in a hybrid module, the chip reduces the overall component count and package size, is relatively easy to design in, and delivers performance that is comparable to a discrete VCO module.

The IBM3100 is fabricated with HBTs using the company's SiGe process and CMOS logic devices. It is built on a 2.3 × 1.2-mm flip chip using low-temperature C4 bump interconnects that reduce the die size and minimize contact inductance. This permits VCO operation up to 2.5 GHz, making it suitable for multiband digital wireless handsets running the most popular communication standards: GSM at 894 MHz, DCS at 1785 MHz, and PCS at 1910 MHz. The IC operates on a +2.5-VDC supply voltage, allowing module manufacturers to inventory a single IC that meets a diverse range of hybrid VCO-module applications.

GSM and DCS/PCS VCOs offer separate high-power outputs (+7 dBm) and a single low-power prescaler output (−4 dBm). Current consumption is 23 mA in the GSM band, 30 mA for DCS/PCS, and 4 mA for the prescaler output, all with a +2.5-VDC supply.

With regard to the critical phase-noise performance, a typical specification is less than −134 dBc/Hz at 3 MHz offset from the carrier for all frequency bands (GSM, DCS, and PCS). In the GSM band at 20-MHz offset, the rating is an impressive −162 dBc/Hz.

Integrated on the chip are the CMOS logic functions that enable switching between two VCO transistors, switching into the standby mode, and selecting between the chip's two PIN diode drivers. A novel bias architecture provides good voltage-pushing performance. This is important in RF oscillators, which in general have poor power-supply rejection (voltage variations that change the frequency of oscillation). The VCO can be supplied as part of the IBM3100EVBA evaluation board for ease of testing. **IBM Microelectronics Div., 1580 Route 52, Building 504, Hopewell Junction, NY 12533-6351; Internet: www.chips.ibm.com.** MRF

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PRODUCT technology

# Waveguide Components Form V-band Links

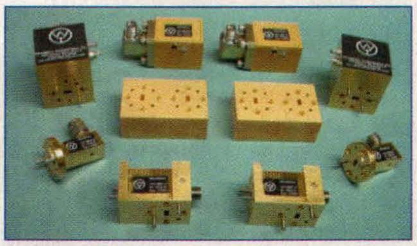
These waveguide assemblies support a 5-GHz channel for high-speed data links and high-resolution millimeter-wave sensors.

**ANDREW LAUNDRIE**
**Contributing Editor**

**Available RF spectrum grows scarce with increasing demands for bandwidth. As a result, service providers seek new channels for transporting data at rates exceeding 500 Mb/s. Fortunately, a new family of V-band components from WiseWave Technologies, Inc. (Torrance, CA) enables the rapid development of short-haul communication links operating license-free from 59 to 64 GHz.**

The WR-15 component family **(see figure)** includes oscillators, multipliers, amplifiers, frequency converters, and coax-to-waveguide adapters. Voltage-tuned oscillators yield +13- to +17-dBm output power across any 1-GHz band within 56 to 65 GHz. Mechanically tuned sources offer +13- to +20-dBm power over a 5-GHz tuning range. Measuring 1.0 × 1.0 × 1.2 in. (2.54 × 2.54 × 3.05 cm), both oscillator types require 750 mA at +3.5 VDC.

Frequency multipliers deliver +16-dBm output power from either a 0-dBm source operating from 28.0 to 32.5 GHz or a +3-dBm source at 14.0 to 16.3 GHz. Both multipliers measure 1.9 × 1.0 × 0.6 in. (4.83 × 2.54 × 1.52 cm), are equipped with K-input connectors, and operate from +8 VDC.



**A line of waveguide components is available for wideband communications links from 59 to 64 GHz.**

Amplifiers include a low-power unit that provides 17-dB gain while delivering +10-dBm output power at 1-dB compression in bands from 59 to 64 GHz. A higher-power unit yields 25-dB gain with +16-dBm output power at 1-dB compression. Both amplifiers feature a 5-dB noise figure with 10-dB return loss. The amplifiers measure 1.0 × 1.6 × 0.6 in. (2.54 × 4.06 × 1.52 cm) and operate from a +8-VDC supply.

Frequency converters handle IF signals from DC to 9 GHz. Upconverters translate an IF input to V-band frequencies, and downconverters perform the opposite function. Balanced converters have less than 8-dB conversion loss . All converters require +13 dBm LO power.

All products are available as separate components or combined as integrated assemblies. WiseWave Technologies, Inc., 4050 Spencer St., Suite E, Torrance, CA 90503; (310) 371-5833, FAX: (310) 371-6393, Internet: www.wisewave-inc.com. MRF

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# LCP Material Now Suits High-Frequency Circuits

These LCP materials feature low dielectric constant and low loss in thin sheets that are suitable for multilayer applications.

PETER STAVENICK
Managing Editor

**Liquid crystalline polymer (LCP) is relatively new to the microwave field. Although LCP circuit-board materials have been commonly used in computer and telecommunications designs, they are yet to see widespread use in microwave applications. But Rogers Corp. (Chandler, AZ) hopes to change all of that, with its ZYVEX® circuit-board materials, a new family of products based on LCP dielectric material.**

The family of LCP circuit materials is made up of single-clad and diclad laminates, bondply, and cover-film products. The dielectric materials can be made into extremely thin layers for fabricating multilayer designs with low signal distortion and high isolation. The materials provide an increase in design latitude when compared to existing materials such as polyimide.

The ZYVEX materials feature a dielectric constant of 2.9 from 1 to 10 GHz. Over that same frequency range, the dissipation factor is 0.002. The surface resistivity is $2.7 \times 10^{13}\ \Omega$, while the volume resistivity is $2.1 \times 10^{15}\ \Omega$-in. ($5.3 \times 10^{15} \Omega$-cm). The dielectric strength is +4000 VDC/mil.

## Low Moisture Absorption

The materials, which feature low moisture absorption, have a thermal conductivity of 0.3 BTU/hr ft °F and a melt temperature of +536°F. The coefficient of thermal expansion (CTE) is 17 PPM/°C and 105 PPM/°C and the glass transition temperature is 230°F. The low moisture absorption also helps to maintain stable electrical and mechanical properties.

These TeraClad laminate products offer a maximum dimensional stability of <0.10 percent with a variation stability of <±0.05 percent. The peel strength is 6 lbs./linear in. with an initiation tear strength of 3.1 lbs. Thickness variation is rated at <±10 percent as standard thickness is 0.002 in. (50 μm). The standard size measures 20 in. (508 mm) wide × 900 ft. (274.3 m) long roll with standard copper (Cu) cladding of 0.5-oz. (17-μm) electrodeposited Cu foil.

Rogers ZYVEX materials are based on Vecstar® LCP films from Kuraray Co. Ltd. of Japan, and are the result of an ongoing development between the two companies. The materials are suitable where high frequency, chemical resistance, and fine-line high-density-interconnect (HDI) requirements are critical. **Rogers Corp., Advanced Circuit Materials, 100 N. Dobson, Chandler, AZ 85224; (480) 961-1382, FAX: (480) 961-4533, Internet: www.rogerscorporation.com.**

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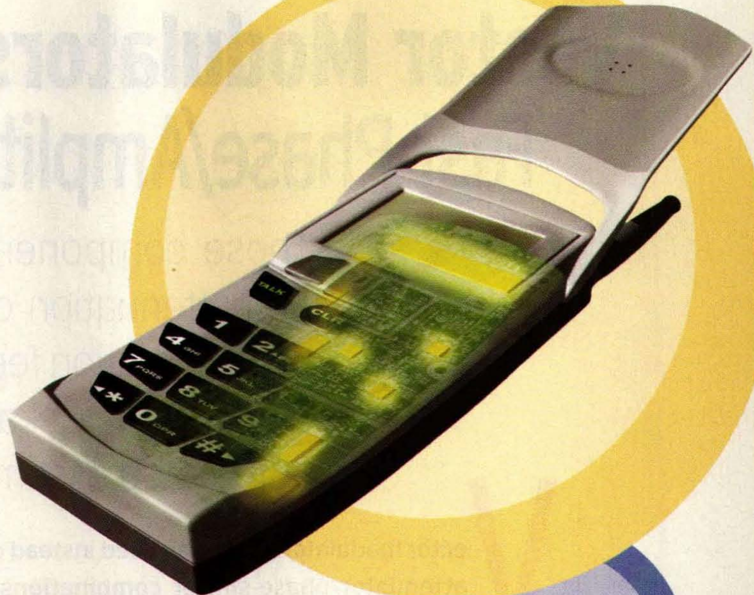



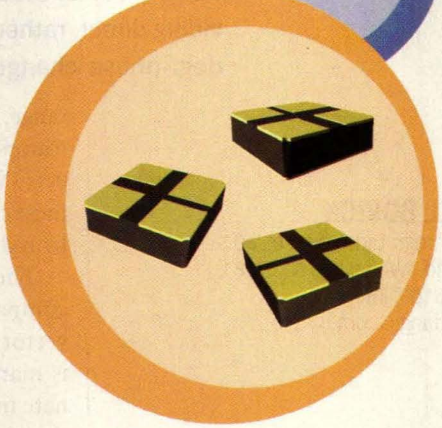

# Vector Modulators Deliver Fast Phase/Amplitude Changes

These components provide the phase and attenuation control that is required of base-station feedforward cancellation loops, in a package that is suitable for automated assembly.

**MICHAEL BORICK**
MCE/KDI Integrated Products, 60 S. Jefferson Rd., Whippany, NJ 07981; (973) 887-8100, Internet: www.kditriangle.com.

**Vector modulators are often used instead of discrete variable attenuator/phase-shifter combinations in base stations. Both approaches are used to vary the phase and amplitude of signals in the cancellation loop of feedforward amplifiers, but the vector-modulator method is inherently faster, providing direct, rather than sequential, access to the full 360-deg. phase change over the full operating temperature** range. The VM-A Series of vector modulators from MCE/KDI Integrated Products (Whippany, NJ) makes the use of these components even more appealing by reducing their footprint and cost.

The VM-A Series differs from the company's earlier ceramic-substrate vector modulators. The VM-A Series is manufactured on microwave laminate materials that are better suited to the 405-to-3000-MHz frequency range (in bands). The firm's earlier vector modulators were small enough, at 1.5 × 1.0 × 0.375 in. (3.81 × 2.54 × 0.952 cm), but the VM-A Series reduces this footprint further, to 0.9 × 0.9 × 0.125 in. (2.29 × 2.29 × 0.318 cm) The VM-A series also employs low-inductance plastic packaging, which simplifies assembly, eliminates wire bonding, reduces manufacturing cost, and allows the VM-A Series to be handled with automated manufacturing equipment. The VM-A Series provides direct access to 360 deg. of phase shift, as well as 0 to 14 dB of attenuation from −35 to +85°C. They are rated for maximum RF input-power levels to 1 W, with less than 10-dB insertion loss **(see table).**

**The VMA Series vector modulators at a glance**

| FREQUENCY RANGE | SIX STANDARD MODELS IN BANDS BETWEEN 405 MHZ AND 3 GHZ |
|---|---|
| Phase-shift range | 0 to 360 deg. |
| Attenuation range | 0 to 14 dB |
| Third-order intercept point | +41 dBm |
| Phase vs. attenuation change | +/− 2 deg. |
| Attenuation change vs. phase | +/− 0.3 dB maximum |
| Operating temperature range | -35 to +85°C |

Two vector modulators are used with two PAs in a typical feedforward cancellation loop. The first samples signals before and after being processed by the first PA, making phase and amplitude adjustments to cancel undesired signals, ideally leaving only the signals of interest. These signals are then sampled before and after being driven by the second amplifier, and adjustments are made through the second vector modulator to eliminate undesired signal contributions from the second PA.

The VM-A Series vector modulators are available in two package styles, and custom physical and electrical configurations can be specified. P&A: less than $12.00, stock. **MCE/KDI Integrated Products, 60 S. Jefferson Rd., Whippany, NJ 07981; (973) 887-8100, Internet: www.kditriangle.com.**

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# DDS Module Shaves Spurious Noise

## This compact DDS module provides the fast switching speed, high resolution, and low spurious noise needed to simplify mixer/divider circuitry in modern communications systems.

**JACK BROWNE**
**Publisher/Editor**

**Digital generation of RF signals has offered tremendous promise for more than a decade. But direct-digital-synthesizer (DDS) technology has long been plagued by high spurious content, due to quantization effects, most notably in the numerically controlled oscillator (NCO) and digital-to-analog-converter (DAC) circuitry. With typical spurious performance of –80 dBc, however, the new MS-2002** *WaveCor* complementary-metal-oxide-semiconductor (CMOS)-based DDS module from ITT Industries, Microwave Systems (Lowell, MA) breaks with tradition by minimizing spurious products while keeping the benefits of DDS technology, including high frequency resolution and fast switching speed.

The MS-2002 *WaveCor* DDS module **(see figure)** is designed for operation at output frequencies that are approximately one-quarter the clock frequency—an output range of 2.0 to 22.5 MHz for a clock rate of 100 MHz. The MS-2002 DDS can operate in either continuous-wave (CW) or chirp-output mode. It features a 64-b phase/frequency accumulator for better than 0.01-Hz frequency resolution and better than 0.01-dB amplitude resolution. The frequency-switching speed of a DDS module is generally limited by the DAC and the filters that follow it. For the MS-2002, the frequency-switching speed across the full output range—the time required to turn a digital control signal into a new frequency—is a lightning-fast 480 ns. The phase noise of the MS-2002 is less than –100 dBc/Hz offset 1 kHz from the carrier.

The MS-2002 *WaveCor* DDS module is supplied in a housing that measures 4.0 × 5.0 × 0.6 in. (10.16 × 12.70 × 1.52 cm) with ribbon-cable connectors. It weighs just over 0.5 lb. and requires only an external 100-MHz clock oscillator and a simple output anti-aliasing filter. Up to 16 MS-2002 units can be cascaded together for complex signal arrangements. The DDS module includes a serial low-voltage-differential-signalling (LVDS) interface for simple integration with host control devices. An optional *WaveCor* test kit, with a voltage regulator board, personal-computer (PC) interface cable, and control software is also available. Optional bandwidths and clock speeds are also available, and future models will also include a digital in-phase/quadrature (I/Q) modulation port. **ITT Industries, Microwave Systems, Advanced Engineering and Sciences, 59 Technology Dr., Lowell, MA 01851; (978) 441-0200, FAX: (978) 453-6299, Internet: www.ittmicrowave.com.**

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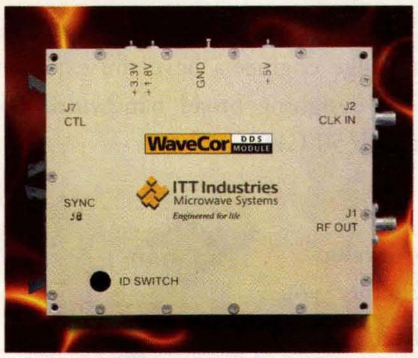
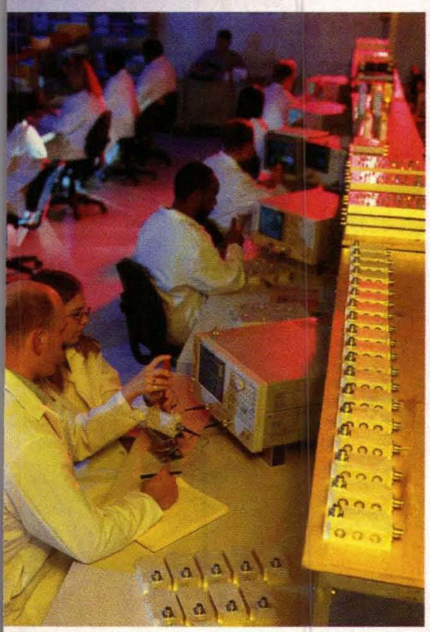


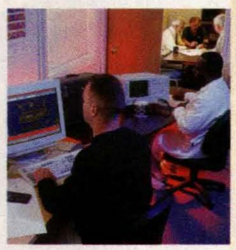

**The MS-2002 *WaveCor* DDS module is a CMOS-based 2.0-to-22.5-MHz synthesizer that is capable of 480-ns frequency-switching speed when operating at a 100-MHz clock rate.**

# Lorch Microwave: Multi-product Solutions for Commercial Wireless Applications

With over 35 years experience designing and manufacturing microwave components, Lorch Microwave provides filtering solutions to the commercial market

- from base station to microwave radio links
- from less than 1MHz to 40GHz
- from high volume to small custom runs





Diverse engineering and manufacturing capabilities allow Lorch Microwave to quickly respond to customer needs and provide custom tailored solutions, all with trademark service and satisfaction.

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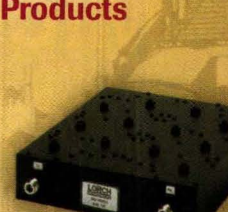

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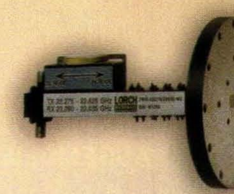
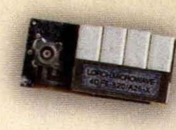
- cellular and PCS base stations filters, duplexers and assemblies
- delay assemblies for feed forward amplifier applications



### WAVEGUIDE DIPLEXERS

- point-to-point microwave radio links to 40GHz
- terrestrial communication networks



### CERAMIC FILTERS

- filters and diplexers to 5.8GHz
- specialized cellular and PCS applications
- diplexers and finite pole placed topologies available

### OTHER COMMERCIAL AND MILITARY APPLICATIONS

- cavity filters
- discrete filters
- tunable filters
- other signal processing products

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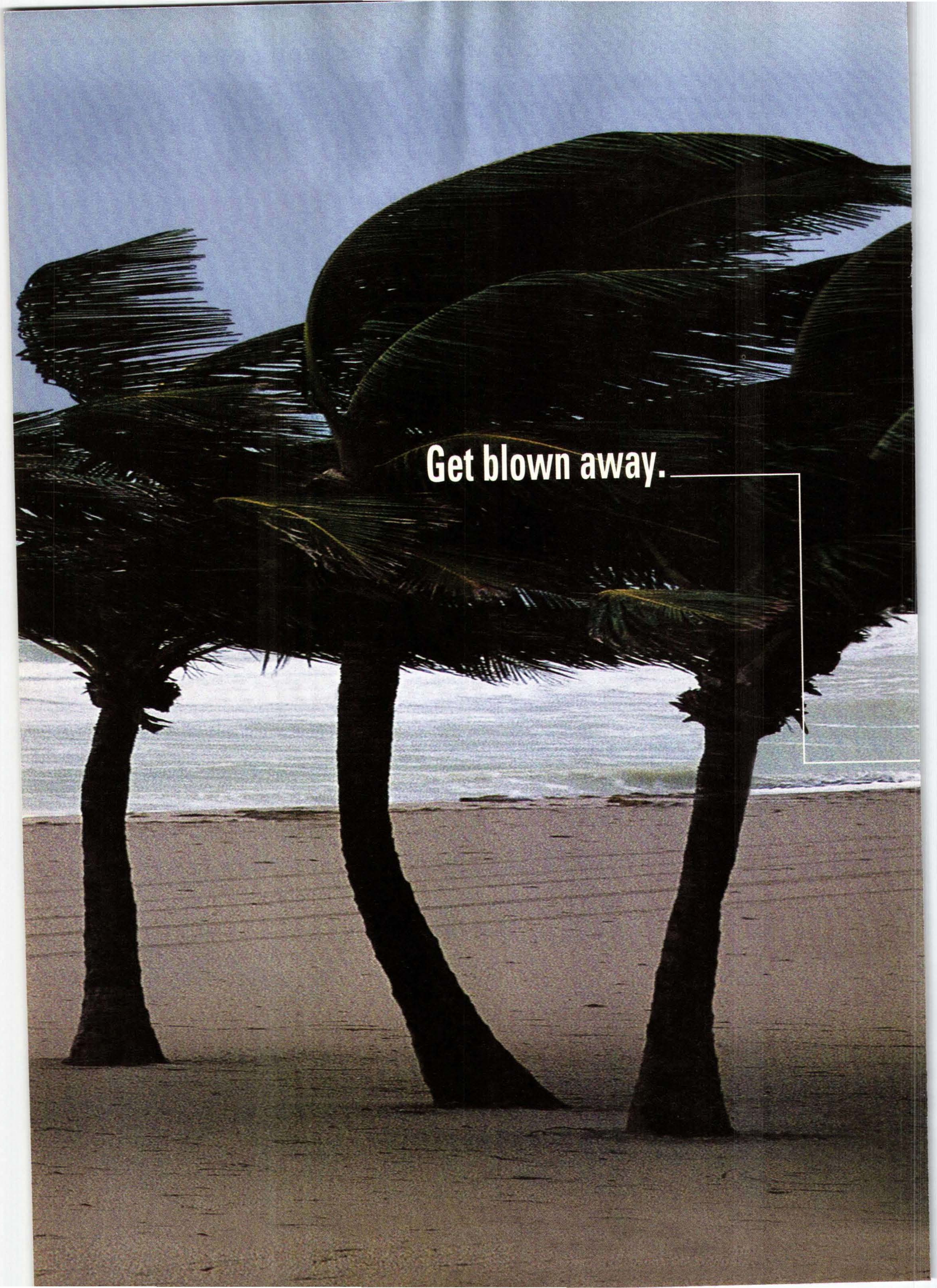
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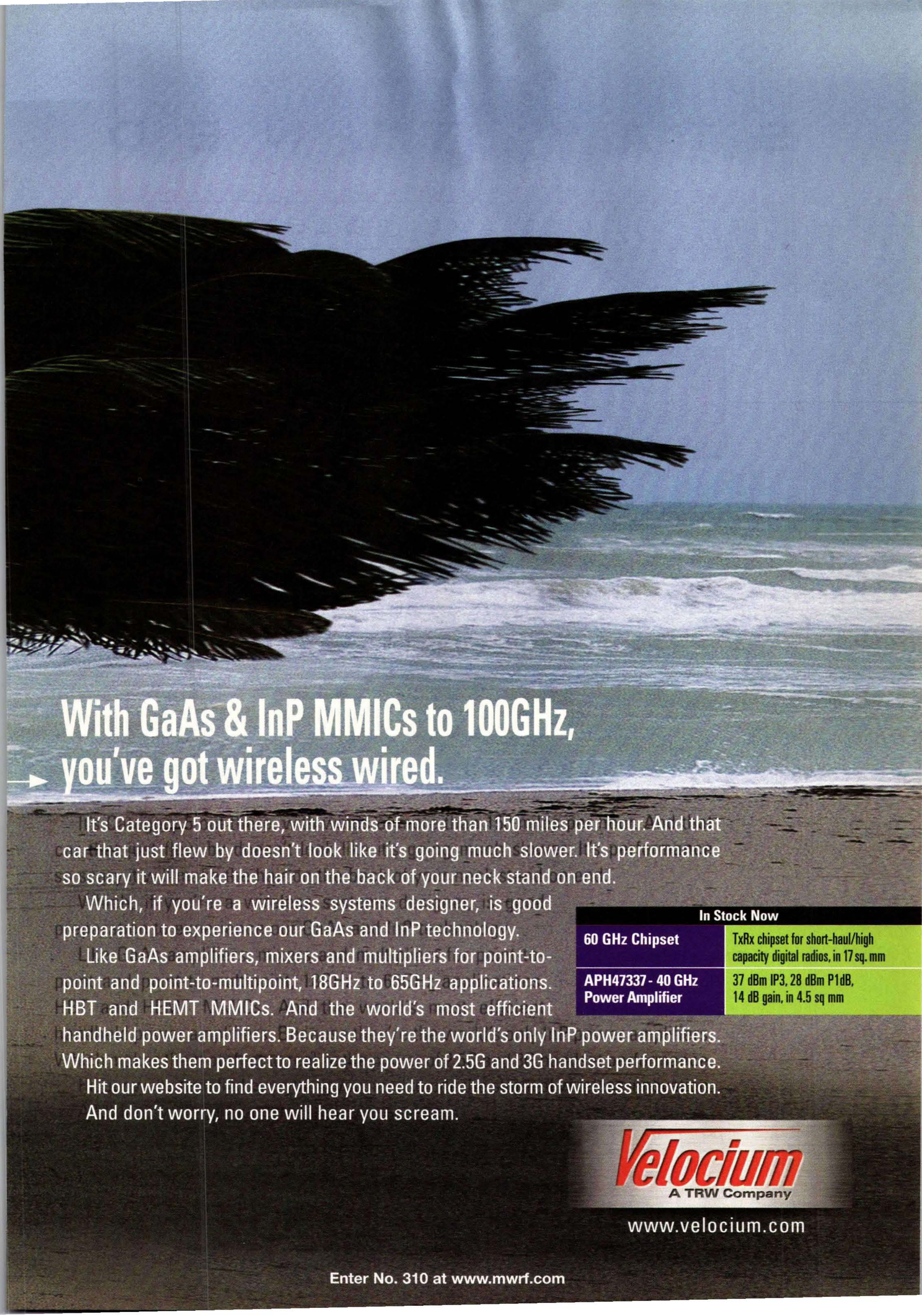
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## Amplifier Provides 45-dB Gain-Control Range

THE MODEL AD8369 digitally controlled variable-gain amplifier (VGA) is designed for use from low frequencies to 500 MHz and provides very-flat gain response across all gain settings. The device provides a gain-control range to +40 dB that is adjustable in 3-dB increments and controllable through a 4-b digital interface that may be configured in either serial or parallel model. The VGA is a differential input/differential-output device with a high-efficiency output stage that provides low intermodulation distortion (IMD), enabling the unit to be used with high-performance 12-b analog-to-digital converters (ADCs). The unit has been specified for use within next-generation second-and-a-half-generation/third-generation (2.5G/3G) equipment employing higher and wider-dynamic-range intermediate-frequency (IF) sampling architectures. P&A: $4.20 (1000 qty.).

**Analog Devices, Inc., 804 Woburn St., Wilmington, MA 01887; (800) 262-5643, (781) 937-2824, FAX: (781) 937-1021, Internet: www.analog.com.**
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## Transducers Support Audio Electronics

THE MQT SERIES of audio transducers that operates over the temperature range of −30 to approximately +70°C. Models MQT-E and MQT-F have minimum sound output of 87 dB at 10 cm, while the MQT-G and MQT-H have minimum sound output of 90 dB at 10 cm. Models MQT-E and MQT-G have side sound ports, while the MQT-F and MQT-H are designed with top sound port. Mean current consumption of all models is 80 mA maximum at the rated voltage of 2670 Hz. Models MQT-E and MQT-F measure 8.5 × 8.5 × 3.2 mm and the dimensions of the MQT-G and MQT-H are 8.5 × 8.5 × 4.0 mm. All models weigh 4 g and the transducers are well-suited for design into any compact electronic product requiring sound, including pagers, cellular phones, and personal digital assistants (PDAs). P&A: $2.00 (OEM qty.); 8 to 12 wks. ARO.

**Star Micronics America, Inc., 1150 King Georges Post Rd., Edison, NJ 08837-3729; (800) STAR-OEM ext. 523, FAX: (732) 623-5590, e-mail: audiocomponents@starus.com, Internet: www.starmicronics.com.**
**Enter No. 67 at www.mwrf.com**

## DSP Tool Features Code Generator

SYSTEMVIEW VERSION 5.0 is a wireless/digital-signal-processing (DSP) system design tool that allows users to design wireless systems and create optimized fixed-point C code that can be ported directly for use on Texas Instruments' DSPs with a mouse. The system's generated C code meets TMS320 algorithm standard to facilitate eXpressDSP™-compliant algorithm development. The system exports readable and efficient ANSI C code for individual tokens, subsystems, and full systems designed in SystemView. Fully automated optimization is provided for x86, and Texas Instruments' TMS320C5000™ and TMS320C6000™ platforms. A customization option supports code generation for virtually any processor and DSP library tokens generate fixed-point C Code.

**Elanix, Inc., 5655 Lindero Canyon Rd., Westlake Village, CA 91362; (800) 535-2649, FAX: (818) 597-1427, e-mail: elanix@elanix.com, Internet: www.elanix.com.**
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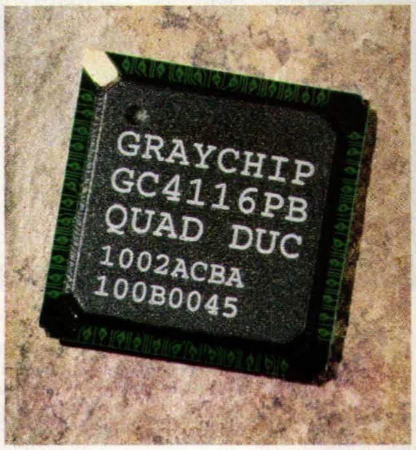
## Gaskets Sport Shielding To 100-dB Attenuation

TWO LOW-PROFILE BERYLLIUM-COPPER (BeCu) gaskets (60P21 and 125G32) offer RF-interference/electromagnetic-interference (RFI/EMI) shielding effectiveness up to 100-dB attenuation. The gaskets measure 0.08 in. (0.20 cm) high. Stick-on mounting simplifies installation and may be used at ambient temperatures from −67 to 300°F. The gaskets are suitable for bidirectional applications, require only a low closing force, and provide 360 deg. of snag-free operation.

**Tech-Etch, Inc., 45 Aldrin Rd., Plymouth, MA 02360; (508) 747-0300, Internet: www.tech-etch.com.**
**Enter No. 69 at www.mwrf.com**

## Upconverter Offers Four Narrowband Channels

MODEL GC4116 IS a wideband-code-division-multiple-access (WCDMA) four-channel digital upconverter chip that is suitable for third-generation (3G)




wireless base stations. The unit features two 5-MHz WCDMA channels and four narrowband channels. Channel performance provides 115 dB of spurious-free dynamic range (SFDR). Power dissipation is 107 mW/channel when clocked at 70 MHz and configured for Global System for Mobile Communications (GSM). The overall interpolation range can be set from 16 to 5792. Each channel digitally upconverts and filters signals of interest from baseband sources at sample rates up to 106 MSamples/s.

**Graychip, Inc., 2185 Park Blvd., Palo Alto, CA 94306; (650) 323-2955, FAX: (650) 323-0206, e-mail: sales@graychip.com, Internet: www.graychip.com.**
**Enter No. 70 at www.mwrf.com**

## Filter Boasts 70-MHz Center Frequency

MODEL KR2395 IS a high-performance, surface-mount, elliptic bandpass filter that has a center frequency of 70 MHz with a 1-dB bandwidth of 12 MHz. The filter provides a stopband attenuation of typically more than 60 dB. the footprint size is 0.5 × 1.5 × 0.3 in. (1.27 × 3.81 × 0.76 cm). Other center frequencies and bandwidths can be customized.

**KR Electronics, Inc., 91 Avenel St., Avenel, NJ 07001; (732) 636-1900, FAX: (732) 636-1982, e-mail: sales@krfilters.com, Internet: www.krfilters.com.**
**Enter No. 71 at www.mwrf.com**

## Antenna Boasts 2.0:1 VSWR

MODEL 506051E IS an embedded antenna that is used in wireless local-area-network (WLAN) and IEEE 802.11 RF identification (RF ID) applications. Operating over the 5.25-to-5.35-GHz frequency range, the antenna has a VSWR of 2.0:1, an impedance of 50 Ω, and is linearly polarized. The antenna is custom designed to specific size, weight, shape, and performance.

**TECOM Industries, Inc., 9324 Topanga Canyon Blvd., Chatsworth, CA 91311; (800) 730-4010, (818) 341-4010, FAX: (818) 718-1402, e-mail: webmaster@tecom-ind.com, Internet: www.tecom-ind.com.**
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## Amplifier Delivers 49-dB Gain

A TWO-WAY MESSAGING and wireless interactive communication base-station power-transmit amplifier operates from 929 to 941 MHz and develops 130-W average output power. The unit provides 49-dB gain and 15-percent DC-to-RF efficiency. When specified with four modulated carriers, adjacent-channel power ratio (ACPR) is −33 dBc at ±37-kHz offset. The amplifier features microprocessor control, status monitoring, and programmable gain and phase control. A 19-in. (48.26 cm) rack-mounted chassis configuration that accepts up to four power-amplifier (PA) units is available.

**AML Communications, 1000 Avenida Acaso, Camarillo, CA 93012; (805) 388-1345, FAX: (805) 484-2191, e-mail: sales@amlj.com.**
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## Terminations Span DC to 40 GHz

MODEL T3M IS a precision coaxial termination that ranges from DC to 40 GHz. Maximum VSWR is 1.2:1. The terminations were subjected to thermal-shock testing per MIL-202, Method 107, and Test Condition B. They also underwent

five cycles of thermal shock throughout the −65 to 125°C temperature range, which enables temperature testing of components using these terminations. The standard connector is 2.4 mm male. P&A: $245.00; stock to 3 wks.

**Krytar, 1292 Anvilwood Ct., Sunnyvale, CA 94089; (408) 734-5999, FAX: (408) 734-3017, Internet: www.krytar.com.**
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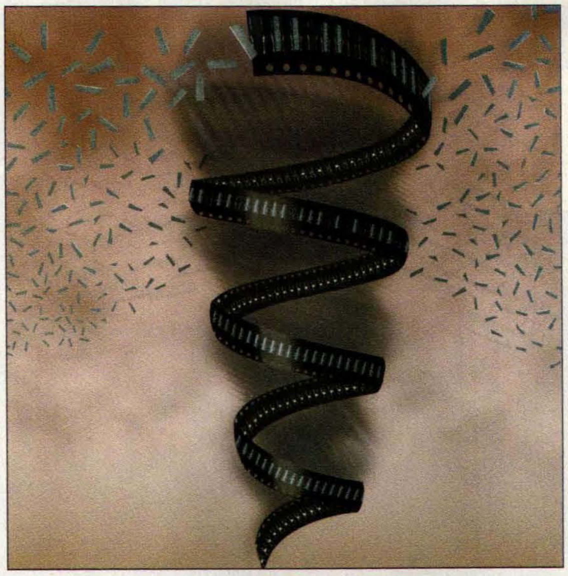

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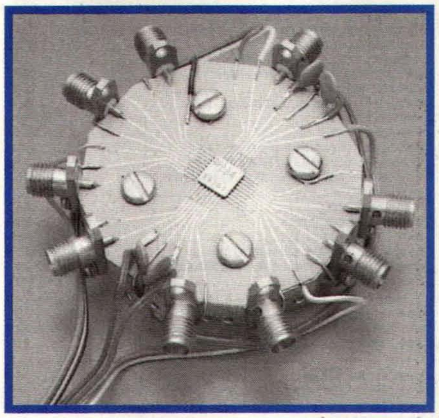

JUST OVER 17 years ago, manufacturers of gallium-arsenide (GaAs) integrated circuits (ICs) , including Harris Microwave Semiconductor (Milpitas, CA) and GigaBit Logic (Newbury Park, CA) developed evaluation kits to promote the use of digital GaAs ICs through 2.5 GHz.

# next month

## Microwaves & RF June Editorial Preview

## Issue Theme: Military Electronics

### News

The June issue will feature several roundups of key technical conferences and industry events. One report will offer a summary of the recent RF & Hyper Europe Conference and Exhibition (March 26-28, 2002, Paris, France), with a sampling of new products from the show. Another report will provide the highlights of the recent ARMMS RF & Microwave Society Meeting at the Hotel Elizabeth (Corby, Northamptonshire, England). An additional report will summarize the current state of millimeter-wave technology and size up applications above 40 GHz.

### Design Features

Technical articles in June cover a wide range of technologies from devices to test methods. The use of combined load- and source-pull techniques to improve the efficiency and linearity of PAs and how to apply open-source computer-aided-engineering (CAE) software to the design of narrowband inductive-capacitive (LC) bandpass filters will be explored. Additional articles will examine the construction of a Schottky-diode-based single-balanced mixer for Unlicensed National Information Infrastructure (UNII)-band applications from 5 to 6 GHz and how to employ statistical-analysis methods to improve the yield of monolithic-microwave-integrated-circuit (MMIC) designs.

### Product Technology

The lead new-product introduction in June is a high-speed, modular direct frequency synthesizer. Featuring microsecond switching speed and low phase noise, initial models will cover wireless communications bands. Additional product stories will unveil a wideband vector-network-analyzer (VNA) system that works with modulated test signals, a miniature Global Positioning System (GPS) receiver (Rx) IC, and a low-cost, second-generation (2G) Bluetooth chip set designed for embedded applications in cellular handsets.

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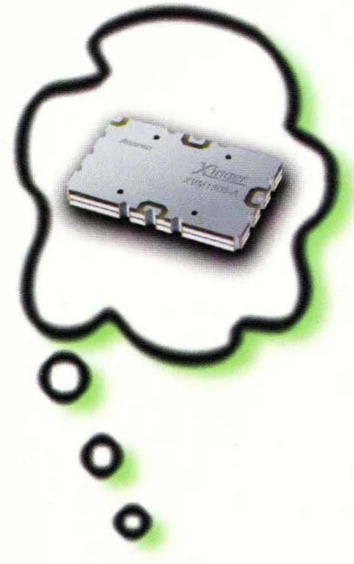

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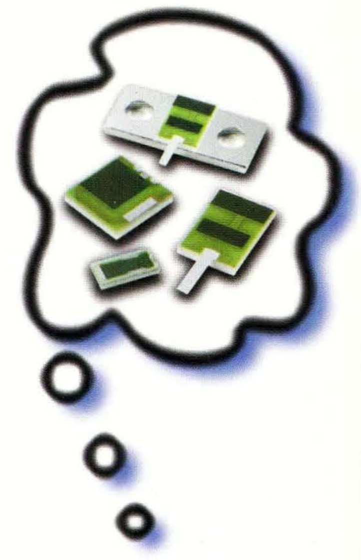

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